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MULTIPURPOSE MODIFICATION OF PLAYA  
SINKS

Lubbock City-County Health Unit  
Lubbock, Texas

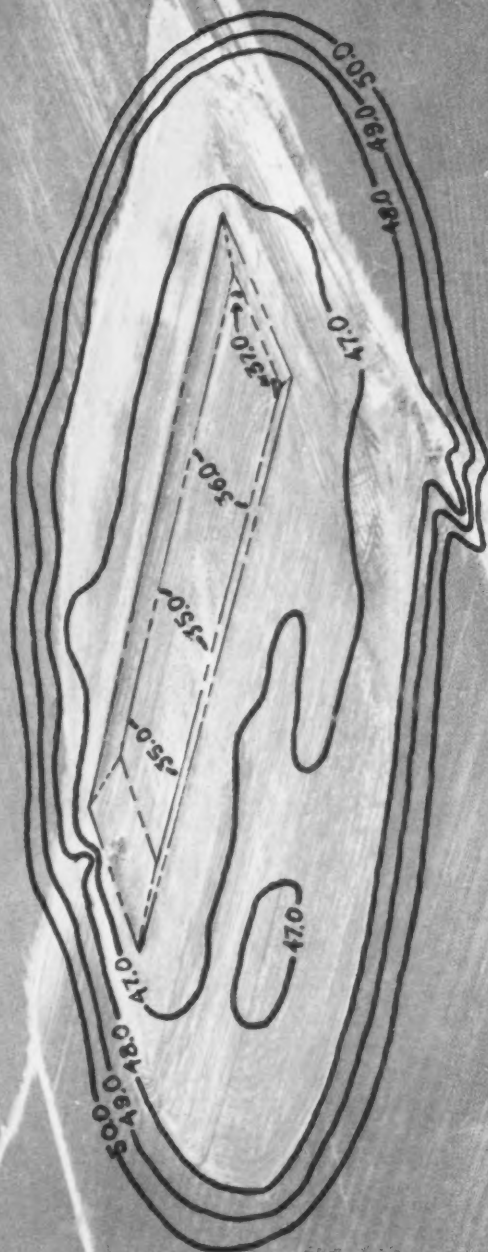
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# MULTIPURPOSE MODIFICATION of PLAYA SINKS



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SECOND ANNUAL PROGRESS REPORT

Lubbock, Texas  
December 31, 1963

MULTIPURPOSE MODIFICATION  
of PLAYA SINKS ✓

PROJECT NUMBER 29 DIVISION OF WATER SUPPLY AND POLLUTION CONTROL  
UNITED STATES PUBLIC HEALTH SERVICE

PRESENTED BY

LUBBOCK CITY-COUNTY HEALTH UNIT

in cooperation with

HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT

TEXAS TECHNOLOGICAL COLLEGE

UNITED STATES PUBLIC HEALTH SERVICE

TEXAS STATE DEPARTMENT OF HEALTH

TEXAS WATER COMMISSION

INTRODUCTION

PART I

BIOLOGY AND ECOLOGY OF PLAYA LAKES

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PART III

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## ACKNOWLEDGEMENTS

A project of such wide significance to the public health, agriculture, and wildlife of a major locality draws the interest, support, and cooperation of many agencies and individuals.

Mr. Walter Breedlove, Chief Public Health Engineer of the Lubbock City-County Health Unit has for years fostered and sponsored the development of the research problems represented by this project. His efforts in securing and organizing the project, his keen interest, excellent advice, and continuing support of this study are especially appreciated.

Dr. A. D. Hess and colleagues Marshall Rainey and Bruce Francy of the USPHS, Greeley, Colorado, have been very helpful in planning the program, resolving technical problems, and securing equipment.

Dr. J. V. Irons, Director of the Laboratory, and Frank J. VonZuben, Jr., and Dr. John S. Wiseman of the Texas State Health Department, and colleagues have aided in conducting certain water and chemical analyses and have given their advice and support to the project.

Don Kriebel, M. G. Sheldon, and Phillip Summers, United States Fish and Wildlife Service, have assisted in cataloging and identifying vertebrate species and in planning the wildlife phases of the project. Professor Chester Rowell of the Biology Department, Texas Technological College, has certified or identified specimens of the higher plants collected in the study.

John Hobbs, of the Public Information Office, Texas Technological College, has been most helpful in arranging some photography and publicity for the project.

The Texas Water Commission has supplied the automatic water level recorders.

Special recognition is extended to the High Plains Underground Water Conservation District for supplying office space and equipment.

Dr. B. J. Sandlin, Physics Department, Texas Technological College, has devoted much time and energy in the development of a portable recorder for use in the biological phases of this project.

The following have also helped as advisors and consultants:

Dr. J. R. Johnston of SWCRD-ARS-USDA--Amarillo  
J. T. Musick of SWCRD-ARS-USDA--Amarillo  
Y. E. McAdams of SCS-USDA--Lubbock  
Tom Cowan of SCS-USDA--Lubbock  
Dave Sherrill of Texas A & M Extension Service  
Al Couch of City of Lubbock, Director of Finance  
Cecil S. Williams, Director of Wildlife Research, Denver, Colorado  
Dr. Thadis W. Box, Agronomy Department, Texas Technological College

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## INTRODUCTION

The landscape of the High Plains of West Texas is marked with thousands of temporary impoundments called playa lakes. For centuries they have dotted the countryside, providing a temporary water resource during periods of high rainfall only to become dust bowls when evaporation, transpiration, and percolation have evacuated their shallow supplies.

As agriculture encroached upon the range, these areas became waste land, ill favored because of their habitual inundation during the spring growing season, and their void expanse when water became necessary in the late summer. Their presence was even less appreciated because their shallow, tepid waters proved to be an ideal breeding site for mosquitoes.

As underground water resources have been tapped for irrigating, the playa has assumed the new role of natural catch basin for runoff or "tail water" from row-irrigated crops. This small amount of "tail water" in combination with frequent thunderstorms during the spring and summer months greatly enhances the mosquito-producing capacity of the playas, and, since there is a remarkably uniform distribution throughout the region, has brought massive mosquito breeding to essentially every townsite.

The development of the region into a major Western Equine Encephalitis endemic site spurred control efforts on the playa breeding sites, and stimulated major control applications of effective insecticidal chemicals. These, plus the possible accumulation from crop applications on the watershed, warrant studies concerning the possibility of contamination of underground water resources. Many such problems are subjects of intensive study in the project reported here.

There are several theories on the origin of the playa lakes, but the one that is generally accepted involves three factors. The alluvial deposits have a heterogeneous nature which resulted in differential settling. Runoff collected in the lower areas and percolation resulted in the removal of soluble and colloidal materials. These depressions were further widened and deepened by wind erosion.

The High Plains of Texas consists of approximately 35,000 square miles and it has been estimated that there is an average of one playa lake per square mile. They range in size from a few yards to a mile in diameter and from a few inches to fifty feet in depth. Water holding characteristics vary, with many playas containing thick layers of clay and colloidal materials which, when wet, become relatively impermeable and hold water to be lost through evaporation and transpiration. Data collected by the U. S. Geological Survey and the Texas Water Commission shows that a large portion of the water which collects in the playa depressions is lost back into the air in this manner. A Study of 1,348 lakes in four counties indicated that in 1957, an above normal rainfall year, the lakes impounded 200,000 acre feet of water. In 1958, a below normal rainfall year, the lakes impounded approximately 35,000 acre feet of water.

It was estimated in 1958 that 160,000 acre feet of recoverable ground water remained in the Ogallala underground reservoir of the Southern High Plains of Texas. Withdrawal of 3,000,000 to 5,000,000 acre feet of water per year by about 44,000

wells which irrigate approximately 4,300,000 acres of land is depleting this water supply. The Ogallala formation has been isolated, through erosion, from any water-bearing beds outside the area, except underlying older rocks which contain highly mineralized water. As a result, the source of all water entering the Ogallala formation is precipitation which falls on the plains of Texas and New Mexico. The average annual precipitation is about 20 inches and about 5% or one inch of it finds its way into the playa where it is usually lost.

With the economy of the area mostly dependent upon irrigated agriculture, any practical water conservation methods developed by this study will be of notable value to this area's economy. In the past, the playa lake not only represented water lost to the economy, but, when flooded, the playa lakes represent hundreds of acres of valuable land lost for an economic return. With the cost of irrigated land ranging up to \$1,000 per acre, recovery of this land would seem desirable. Although additional land for farming may not seem necessary in light of the present surpluses, with the population of the world expanding at the rate of 140,000 people per day, it seems feasible to assume that the surplus problem will be a temporary one, and that the real problem may eventually be one of finding enough tillable land to feed the people.

It has been well established, through studies by the U. S. Public Health Service and the Texas State Health Department, that playa lakes form the major habitat for the vector of arbor encephalitis in Western Texas. In a study by the Encephalitis Section of the USPHS in 1954, playa lakes in the study area accounted for approximately 75 per cent of the mosquito production. During the seven-year period of 1954-60 in eleven counties in Northwest Texas, 460 cases of infectious encephalitis were reported to the Texas State Health Department. In 1955, an epidemic of mixed WE and SL encephalitis occurred in Northwest Texas. Attack rates of encephalitis ranged from 1 per 1,000 up to 2 per 1,000 population in some counties.

The history of the endemicity of encephalitis viruses extends back for many years from the reports of equine encephalitis. Recent work, started in 1958 in Hale and Lubbock Counties by the Encephalitis Section, USPHS and continuing through the present, shows a very high degree of virus activity in these areas. Numerous isolations of Western and St. Louis virus have been made from the collections of Culex tarsalis and Culex quinquefasciatus by the Texas State Health Department, the Encephalitis Section, CDC, and the National Biological Institute, Hamilton, Montana.

That the vectors are abundant is shown by repeated collections of up to 4,000 mosquitoes in a light trap in a single night in the area around Hale Center in Hale county. With the high degree of virus activity and the abundance of the vectors, the possibility of outbreaks of epidemic proportions is always present.

With the increased urbanization of many areas of the plains, the problems of pest and floodwater mosquitoes also become increasingly important. In the case of the City of Lubbock, urbanization has spread to the point that a good portion of the residential areas is in close proximity to playa lakes, thus exposing large numbers of people to the mosquitoes produced in these areas. With the extremely high levels of relief from mosquito annoyance enjoyed in many other areas of the country, the Lubbock city residents will increasingly demand more efficient control of mosquitoes.

Playa lakes of the Texas High Plains form an integral part of the flight lanes for waterfowl moving to and from the Texas Gulf Coast. In those years with higher than normal precipitation, the many playas help overwinter large numbers of waterfowl. In addition to the importance of these lakes to water fowl, the development of fisheries in the plains area may result from more efficient use of these playa lakes.

With the great potential benefit to all facets of the population and economy of the area, this study is objectively attempting to develop methods for multipurpose modification of playa depressions, which will best adapt them for disposal of sewage effluent, prevention of mosquito production, soil and water conservation and wildlife habitat.

The results of the first year of observations and studies have been presented in the First Annual Progress Report of this Project. During the Fall and Winter of 1962-63, three of the ten original study lakes were modified and this report is the presentation of data collected during the second year with comparisons among modified and unmodified playas and plans and procedures for the coming year.







# Part I

## BIOLOGY AND ECOLOGY OF PLAYA LAKES

Conducted and written by Dr. Ellis W. Huddleston

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Texas Technological College

and

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## BIOLOGICAL PHASES OF THE PLAYA LAKE STUDY

### Introduction

Statistically sound sampling procedures were developed and used in obtaining data on mosquito production during the first season. With these data showing a base line of significant mosquito production in all of the study lakes that impounded water, three of the lakes were chosen for multipurpose modification. Another known mosquito producing playa was selected for a modification designed to maintain a resident population of the top minnow, Gambusia affinis affinis. All of the study lakes were sampled intensively for mosquito production using the techniques developed during the previous season. The three modified playas and one of the original study lakes were chosen for intensive investigations for all phases of the study.

Water chemistry of the playa has been studied with particular emphasis on those chemical components most likely to affect mosquito and fish production. An attempt was made to develop a more suitable technique for estimating overwintering mosquito egg numbers. Laboratory procedures were developed for the culture of two local species of mosquitoes and procedures for a third species are being developed. Larval forms from these cultures were used in laboratory studies to determine the effects of monomolecular films on larval survival. Larvae were also used in laboratory studies using the World Health Organization test kit for the establishment of a base line of susceptibility to certain insecticides and to evaluate effectiveness of local control practices.

Major efforts were devoted to the development of a portable recorder to aid in the continuous recording and accumulation of data on variations in water temperature, air temperature, relative humidity, intensity and duration of rainfall, wind velocity and direction, and elevation of the water surface. Studies on water temperature in relation to air temperature have been made during the 1962 and 1963 seasons using a conventional stem thermometer. This portable recorder will make more detailed studies possible during the coming season. Other areas under investigation include survey and identification of invertebrates other than mosquitoes, wildlife, and vegetation species. Phytoplankton and zooplankton are being studied from both a qualitative and quantitative standpoint.

### A BRIEF SYNOPSIS OF THE CURRENT SEASON

The winter and early spring of the 1963 season were comparatively dry with only one lake, Burgett, impounding water for a short period late in December, but minor mosquito production ensued. In the latter part of March, Knowles' Lake impounded sufficient irrigation tail-water to have significant mosquito production. The first rain with enough surface runoff to cause inundation of one of the lake basins occurred on the watershed of Cox Lake on April 1, 1963. Following this date there were several large rains that resulted in the inundation of all of the lakes to a much higher level than that which occurred during the 1962 season. There were initial hatches of the floodwater species, but the deep water permitted heavy wave action, and produced a clean shore line, with very little emergent vegetation. As a result of these factors only minor mosquito production occurred during the late spring and early summer. As the summer ensued, the water receded and the aquatic and shore line vegetation began to appear and, following a few small rains, mosquito production reached its peak. Most of the unmodified playas were dry by the latter part of August, but three of the modified playas still have several acres feet of impounded water at the time of publication. The weather patterns were rather atypical and all of the study lakes had significantly less overall mosquito production than that which occurred during the previous season.

## MOSQUITO STUDIES

Mosquito studies include those on production of larvae, light trap records of adult forms, laboratory cultures of key species (Plate 1), laboratory and field studies on monomolecular films, insecticide resistance levels, and egg survey.

### LARVAL PRODUCTION STUDIES AND TECHNIQUES

The line transect design, developed during the previous season, was used in sampling mosquito larvae populations on study lakes. This design consists of the placement of a painted lath in the center of the one-foot contour and the establishment of transect lines at 36 degree intervals and marking them with painted laths driven into the soil beyond the shore line. On each sampling date the sampler made his first dip with the one-half pint capacity, white enamel dipper at the edge of the water and continued along the transect line toward the center stake, taking additional samples at thirty foot intervals. At each of these individual dipping stations all pertinent items on the dipping form were completed. This included the recording of the water depth, total percent of the water surface covered by plants, percent of the water surface covered by plants, percent broadleaf weeds, and percent grass, as well as the species of these plants.

The items on the dipping form described above were generally filled in prior to taking a sample in order to allow the water to settle and to minimize disturbance of the larvae. The dip was then made and the total number of larvae dipped and the number in each instar were recorded. Some of the fourth instar larvae were retained and returned to the laboratory for the determination of species composition; the percent Culex tarsalis is presented in Appendix III, Table I. Appendix III also presents the mean number of mosquito larvae per dip on each lake for each dipping date during the past two seasons. The graphs are presented simultaneously to aid in the comparison of mosquito production among all lakes and between the two seasons on a given lake. Figures 1-11A in Appendix III present the dipping data for the current season from March through July. Figures 1-11B in Appendix III present the dipping data from August through December for both seasons of the study. Dipping data prior to August for the first season were not complete enough to allow index calculations. The indices presented in Appendix III were evolved from the formula:

Average number of larvae/ dip / contour X surface acres of water per contour.

All of the study lakes have been mapped on one foot contour lines and the area represented by each contour has been calculated (Appendix I). Additional information will be secured to determine dipping efficiency indices. As there is an apparent correlation between water depth, vegetative cover, species of plants, and mosquito numbers, correlation and regression analysis will be made from data derived from the study.

The average number of larvae per dip varied from zero to 44.2; the indices for total number of larvae varied from zero to 662.9; the fourth instar indices varied from zero to 162.0. In presenting these data separate graphs have been made showing the indices or larval count-date relationship's at the top with surface acres of water and the rainfall for both seasons below. These values are simultaneously presented to help establish and interpret interrelationships of rainfall pattern and inundation of the lake bed on overwintering egg hatch and Culicine egg deposition.

It is particularly important to note that the water level during the current season greatly exceeded the high water level of the previous season; therefore, one would expect



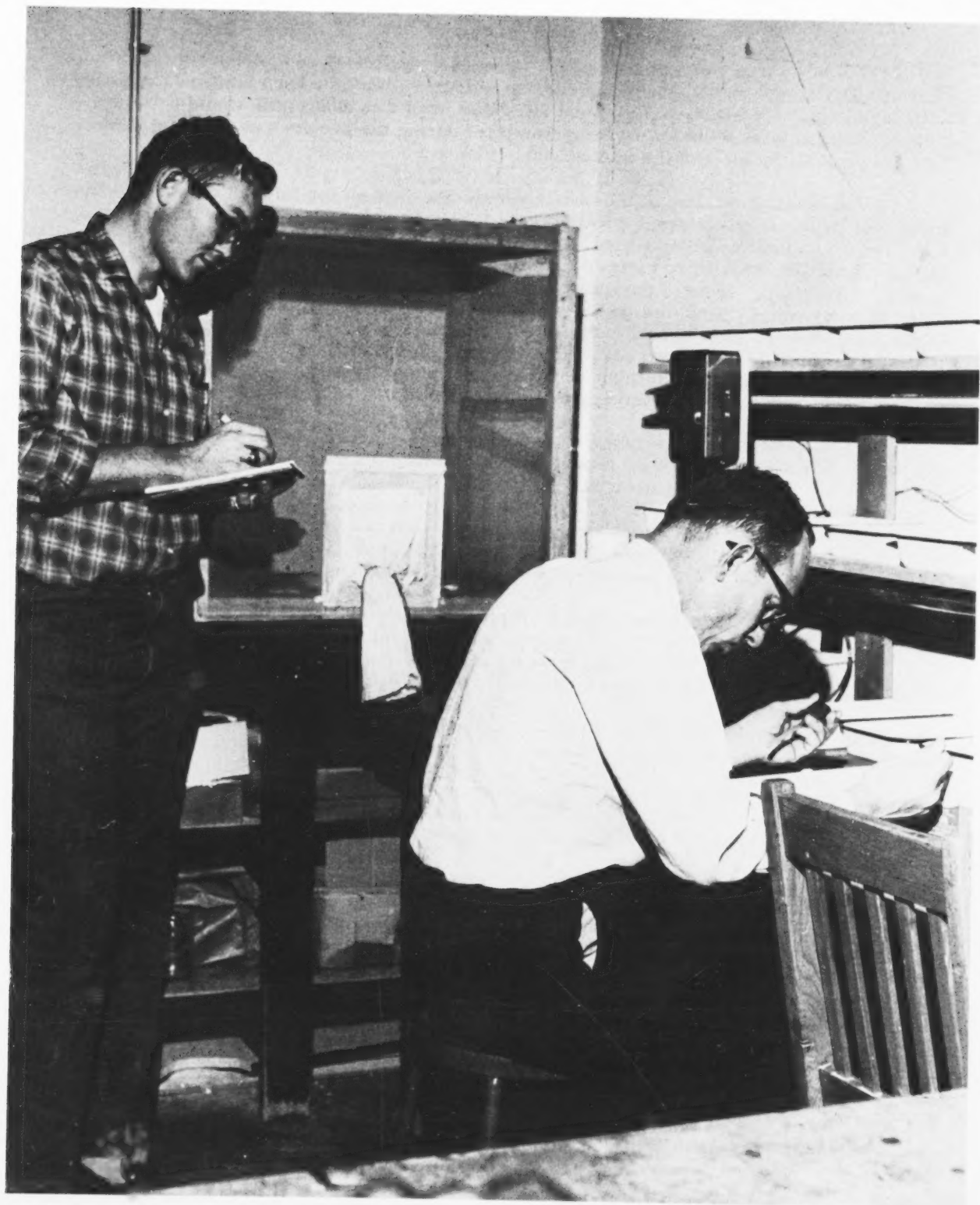


PLATE 1



that there was a large hatch of eggs of the floodwater species deposited during the previous season. During the remainder of the current season the water level remained low and a hatching of eggs deposited earlier when the water level was at its peak would not occur. This would also be expected when the water level during the previous season was higher than the peak water level of the next season.

A visual interpretation of these data shows that, except for initial floodwater hatches, there was little mosquito larvae production following the heavy rains in April. Prior to this, some isolated rains and irrigation tailwater set off initial production in a few lakes. Initial production dates were extremely varied for the ten lakes ranging from March 25 to May 23 (Table I). Most of the lakes impounded water for the first time during the heavy rains in early April. Modified lakes had no mosquito production following the completion of the modification. In addition, no mosquito larvae were observed in one of the unmodified playas, Lake I, Huckabee, although it did have impounded water. The unmodified side of Kitten's Lake had significant mosquito production throughout the season, but the modified side only had minor production in the bar pits.

Several factors must be taken into consideration when evaluating these data. First, the peaks shown on these graphs represent the individuals encountered on a particular dipping date. These dipping dates were up to a week or more apart, and due to the time span, the peaks must be considered as a crude approximation. All of the larvae on a dipping date may have been fourth instar larvae while only a few or no first instar larvae were found the previous dipping date. Thus, allowing for normal mortality, one can see that a much higher peak was most likely reached between sampling dates.

Second, these figures represent a complete sampling of a ten acre or larger area, and not a biased sample from the most productive areas, as is frequently taken for control recommendations. Since each sampling date may represent up to 200 dipping stations with many zero counts, maximums of 300 to 400 larvae per dip are lost in the average.

Third, the numbers in figures 12A and 12B, Appendix III, while of approximately the same order of magnitude, are only an index figure, since they have not been corrected for areas sampled. The bias enters, since all ten transects center on the mid-point of the lake, causing many dipping stations to be in the center of the lake in what is usually deep, open water, not conducive to large numbers of mosquito larvae. The larval indices presented in figures 1-10A and B have been corrected and reduce bias.

Fourth, in evaluating the production graphs in Appendix III it must be remembered that they represent two extremes in the playa lake environment. The first season was extremely dry during the first part of the season, but during the latter part intermittent rains resulted in an abundance of vegetation along the shore line and increased emergent vegetation in the shallow tepid waters. During the current season above normal rains resulted in exceptionally deep lakes which allowed heavy wave actions, little emergent vegetation, and a clean shore line. The first season was very conducive to the production of mosquito larvae, the latter had a negative effect on production. This above normal rainfall essentially gave us a modification of sorts in all of the study lakes during the early part of the season. But as one can readily see, as the water receded and the vegetation established itself mosquito production reached its peak in the unmodified playas.

A summary of the data presented in the graphs and charts in Appendix III shows the average time water was impounded in these ten lakes during the period from March 25



to December 15 was 146.4 days. The maximum length of time water was held by one of these lakes was 254 days for Lake IV, L. C. C.; Lake VIII, Burgett had impounded water for the least amount of time, 67 days, as it was pumped dry by the owner who used the water to irrigate his crops. The average acreage covered by water for the ten lakes was 65.55 acres. This varied from a maximum average of 15.25 for Lake II, Knowles, to a minimum average of 5.69 for Lake IX, Cox. Billingsley Lake had 8.20 feet of impounded water at one time during the period and represents the deepest lake not modified with a large pit. The average index for fourth instar larvae for the ten lakes was 1.74 and the average total instar index was 7.32 per dipping date. Lake V, Kitten, had the maximum fourth instar index average per dipping date of 7.51 and the minimum total instar index average was .04 at Lake VI, Holland. The highest single figures for one dipping date was 662.9 for total number of all larvae index and 162.0 for the fourth instar index, both were on Lake V, Kitten.

STUDIES ON THE MAINTENANCE OF RESIDENT POPULATIONS  
OF Gambusia affinnis affinnis ON PLAYA LAKES

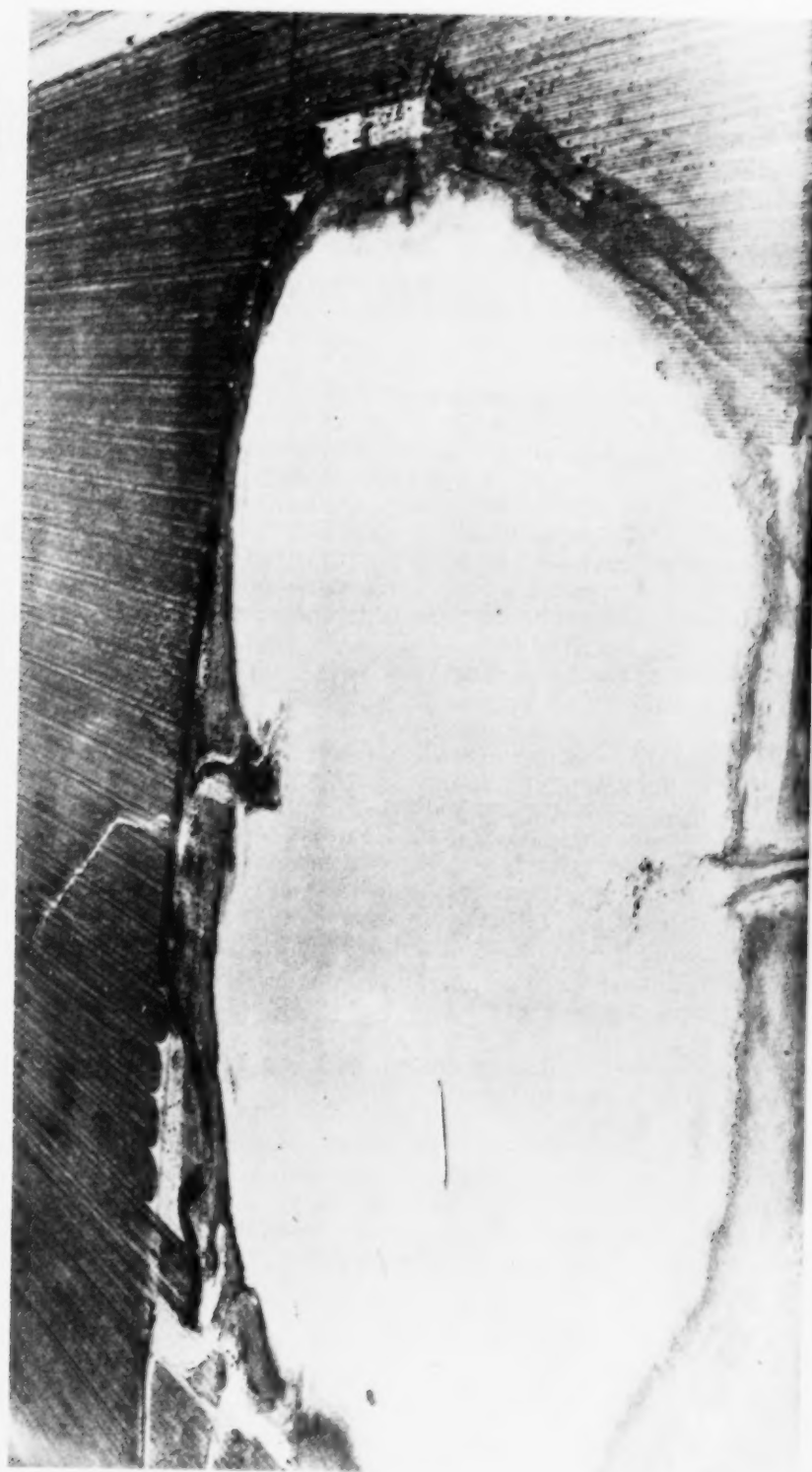
The top minnow, Gambusia affinnis affinnis, commonly called the mosquito minnow, has been used in many localities in attempts to obtain biological control of mosquitoes in permanent bodies of water. This minnow is native to this area and has been included in control practices and is used by the local mosquito control agency when possible. Due to the intermittent nature of the natural playa lake, attempts at stocking them with this minnow have been futile. Studies have been made during the 1963 season on a modification designed to make the playa lake more permanent in order to maintain a resident population of Gambusia affinnis affinnis.

The modification consists of a small pit excavated within the one foot contour of the lake bed. The pit was not placed in the lowest part of the contour, but up on the side of the contour so that only part of the minnow population would be caught in the pit as the lake receded (Lake XI, Appendix I). The pit, 8 feet wide and 80 feet long at the bottom, 10-12 feet wide and 100 feet long at the top, and 6 feet deep, was oriented crosswise to prevailing winds. The spoil from the cut was placed along the west side of the pit, also, to help minimize wave action on the pit (Plate 2). The pit was excavated during the dry winter months and following the inundation of the lake bed in early April, stocking with minnows was initiated. Six gravid females and one male were placed in the lake on the first stocking date, and two weeks later, about mid April, sixty young minnows were placed in the lake. These minnows were obtained with a seine out of a creek, the Double Mountain Fork of the Brazos River, located in the area.

Prior to stocking the lake and before the unusually heavy rains in the early part of April, there was significant mosquito production, but following this no mosquito larvae were dipped on weekly sampling dates. The main lake was dry by October 17 and the only water left was isolated in the pit. During the latter part of November the population was censused using "Mark-Recapture" techniques. The caudal or tail fin of a known number of minnows was notched with scissors and released back into the pit. The following week a sample of the population was taken and the percent of recaptured marked minnows was used to estimate the total population. There were an estimated 2,000 minnows in the pit at that time. At the time of publication the pit contained three feet of water which should be sufficient to carry the minnows through the dry winter and spring months.

This modification was made for a cost of one hundred twenty-five dollars. If future studies substantiate the findings on this type of modification as being successful in mosquito control the cost is low enough that similar modifications could be employed by the local authorities in their control program. Plans are being made to modify three additional lakes in somewhat the same manner and stocking them with Gambusia affinnis affinnis and including them in the studies for the coming season. These modifications will feature variations in pit size, orientation, and methods of soil disposal so that data may be collected to aid in determining the most successful methods to be used in future modifications.





8.1

PLATE 2

LAKE 11 MODIFICATION FOR GAMBUSIA PIT

## LIGHT TRAP RECORDS

Species composition of adult mosquitoes taken in light traps have been analyzed and recorded for several years by personnel of the Lubbock City-County Health Unit. These data provide an information base line to predict peaks in mosquito production from playa lakes. In Figure I, the average number of mosquitoes per light trap night for twelve traps located within the City of Lubbock are presented semi-logarithmically with the percent of the catch that was Culex tarsalis for the past four years.

Suitable electric power source has been obtained at two of the lake sites and some preliminary tests using four light trap designs have been made. The light trap designs employed in these tests were:

1. The Standard New Jersey Light Trap.
2. An ultraviolet-multidirectional trap without fan supplied by USDA, Plant Pest Control.
3. Agricultural Model of "Lura Light," a multidirectional trap employing four circular ultraviolet emitting tubes mounted on a cylindrical fan housing.
4. Home Model of "Lura Light", an unidirectional ultraviolet emitting trap with fan.

The results of these preliminary tests indicate the need of modifying the three latter traps with a screen that will permit only those insects having the approximate same size as the mosquito to be drawn into the trap. Collections were so full of insects other than mosquitoes that separation of the material was very difficult and specimens were not in good enough condition to be properly identified. Trap number 2 was more attractive to several species of water beetles, and traps 3 and 4 were most attractive to the many species of moths in the area. A greater number of mosquitoes were attracted to trap number 3, but due to the condition of the catch and inability to determine species composition, the New Jersey Trap remains as the number one light trap for mosquitoes. Additional tests will be made with the traps properly modified as time permits.

## LABORATORY CULTURES AND STUDIES

Laboratory cultures of Culex tarsalis and Culex quinquefasciatus have been maintained in the laboratory during the past two seasons. Much difficulty was encountered in maintaining the Culiseta inornata culture during the hot summer months. With the acquisition of additional laboratory equipment this species will be kept for studies during the coming season. The larvae from the two established cultures have been used in the conduction of tests on the effects of monomolecular films on larvae when applied to the water surface for evaporation reduction in studies to determine a baseline of insecticide resistance levels and an evaluation of local control practices. Details are being worked out on the instrumentation of a variable temperature cabinet with a programmer for both temperature and photoperiod. Plans are to have the equipment available for laboratory studies during the coming season.

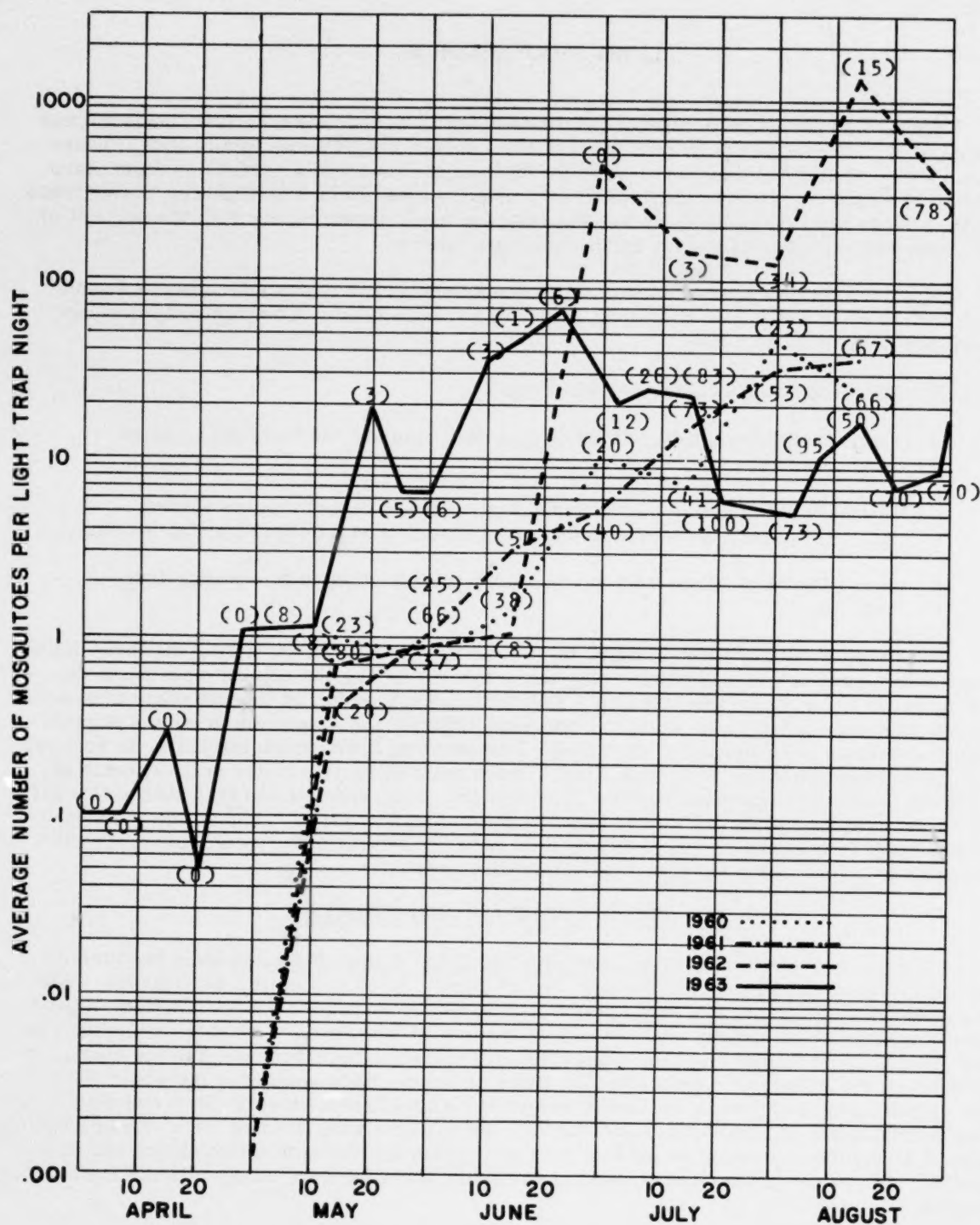


FIGURE 1. AVERAGE NUMBER OF MOSQUITOES PER LIGHT TRAP NIGHT PRESENTED SEMI-LOGARITHMICALLY FOR TRAPS LOCATED WITHIN THE CITY OF LUBBOCK. FIGURES IN ( ) INDICATE % OF TOTAL CATCH THAT WAS *CULEX TARSALIS*. 1960-1963. LUBBOCK, TEXAS.

## LABORATORY CULTURES AND STUDIES

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## MONOMOLECULAR FILM STUDIES

With the desirability of using monomolecular films on playa lakes to reduce evaporation losses, a study was undertaken to determine the effects of these materials on mosquito larvae. Laboratory reared mosquito larvae were placed in containers and four materials were applied to them by two methods. These four materials -- Aqualox, Aldol 52, Alfol 20, and Alfol + -- contained different quantities of several fatty alcohols. Each of the materials were applied (a.) in dry form at various rates, (b.) in solution with ethanol at the recommended rate for evaporation control, and (c.) two and three times that rate. These materials were obtained through Dr. T. R. Crow, Associate Professor, Agricultural Engineering Department, Oklahoma State University, Stillwater, Oklahoma.

When the materials were applied in their dry form they were only slightly higher mortality levels than was observed in the checks; this held true even at very high application rates. When applied in solution with ethanol at recommended rates it was found that mortality was significantly higher than in those checks with equal amounts of ethanol. When applied in solution at 2 and 3 X the recommended rates, total mortality was generally obtained. Checks with equal amounts of ethanol did not show a marked increase in mortality.

Following these positive laboratory tests the films were tested in the fields on small puddles of water containing mosquito larvae. The predominant species in these puddles was Culiseta inornata, as the tests were made in late fall. In these field tests there was no significant reduction in mosquito numbers with either application method or rate of application of any of the materials.

These are only preliminary results and before any conclusions can be drawn additional laboratory and field studies should be conducted. The laboratory studies were made on Culex spp. at temperatures around 75° F to 65° F. There is a possibility that the physically larger Culiseta inornata is more able to penetrate the thin surface film and obtain air than is the smaller Culex spp. The lower temperatures encountered in the field study could also have affected these results.



## INSECTICIDE RESISTANCE STUDIES

Several insecticides have been used extensively in this area for mosquito control. Tests were conducted to determine a base line of susceptibility in local strains and to evaluate the effectiveness of local control practices. These tests were conducted on the insectory strain of *Culex quinquefasciatus*, using the World Health Organization test kit for mosquito larvae. Results of replicated tests are given in Table II.

TABLE II. Comparative mortality results for WHO evaluation of insecticide resistance. Lubbock, Texas, Summer, 1963.

| Concentration<br>in ppm. | Percent Mortality for Various Insecticides |       |       |
|--------------------------|--------------------------------------------|-------|-------|
|                          | Dieldrin                                   | BHC   | DDT   |
| 0.004                    | 4.4                                        | 2.1   | 0.7   |
| 0.020                    | 3.4                                        | 3.3   | 0.1   |
| 0.100                    | 4.1                                        | 2.9   | 19.4  |
| 0.500                    | 5.1                                        | 34.1  | 91.9  |
| 2.500                    | 62.8                                       | 100.0 | 100.0 |
| Control                  | 0.5                                        | 1.2   | 0.5   |

These data show a probable resistance in local mosquitoes to Dieldrin, and will be used as a basis for deletion of dieldrin from the larviciding recommendations. Further evaluations will be conducted as time permits.

## EGG SURVEY

Due to time limitations, little work has been done towards the development of suitable egg survey techniques. Preliminary studies during the 1962 season were inconclusive due to the difficulty encountered in separating eggs from the considerable amounts of organic debris and colloidal inorganic sediments. Limited success was obtained when using the Horsefall equipment and that of the Public Health Service. Efforts at developing another technique for egg separation have been futile.

During the 1962 season the water edge was staked at each dipping date and efforts were made during the winter months to locate the zone of egg deposition. Using the dipping data, light trap records, and the dated stakes, ten areas on one of the study lakes were selected for sampling. One sample was taken from each area for egg separation using the equipment listed above. Attempts were then made to separate the eggs from the soil in the field using two methods. Two cylinders were driven into the soil at each of the sampling areas and fresh water was introduced into one and a saturated salt solution was introduced into the other. The soil was then stirred with a hand operated egg beater in order to dislodge the eggs from the soil. The cylinders were recharged with water and salt solutions as needed and, after allowing time for the settlement of organic debris and colloidal inorganic sediments and the flotation of the eggs, the water and salt solutions were dipped out of the cylinders and placed in separate containers and carried to the lab for final separations and examination with a microscope. Eggs were not detected by either of the three methods from any of the samples from the ten plots. In another study on the same lake, soil samples with undisturbed surfaces were taken into the laboratory and placed in containers and inundated with tap water. Several different organisms appeared, but no mosquito larvae were observed.

The development of a suitable technique for prediction of the finite band of eggs deposited is essential for research on ovicides and other toxicants used for spot treatment of pest mosquitoes. If this band could be located, great economies could be attained in the control of floodwater species. Additional studies will be made during the coming season as this type of approach is essential in the establishment of a mosquito abatement district in this area.

#### WATER CHEMISTRY STUDIES

The playa lake serves as a catch basin for surface runoff and is the end site of many different soluble compounds that the water might accumulate and carry. These compounds and amounts would be expected to vary from lake to lake according to the drainage source of the water as well as the extent of the drainage area.

Complete water analysis was conducted on four lakes the first season in cooperation with the Texas State Department of Health. Due to the time involved in the detailed analyses, no additional samples have been analyzed in 1963. Equipment being secured by our laboratory can be used to continue these analyses.

With the increasing concern about the residues remaining after the application of certain insecticides, studies will be made during the coming season to determine the nature and fate of these residues that find their way to playa lakes. Since these lakes are generally surrounded by cultivated land where valuable crops must be protected from insect damage by insecticide applications, the surface runoff may well be carrying some of the insecticides to the playa. Therefore the playa may receive insecticides from this indirect source as well as from insecticides being applied directly to them for mosquito control. These studies will be conducted by our laboratory, using equipment being secured for the project.

Work presently being carried on by our laboratory consist of field tests made to determine content of dissolved oxygen, free carbon dioxide, pH, and alkalinity. Average content, and range of dissolved oxygen, free carbon dioxide content, pH, and alkalinity of playa water determined in periodic local tests during the current season are presented in Tables I, II, III, and IV (Appendix IV).

The samples were taken with a water sampling device built for the project which uses the principle of an air displacement train. Three general ecological zones of the playa were sampled each sampling date if they were present. A sample was taken along the shore line (SL), another in a zone of emergent vegetation (WZ), and the third sample was taken in open water (OW), generally near the center of the lake which was usually devoid of emergent vegetation.

In addition to these periodic samples a twenty-four hour study was conducted on one of the modified playas, Lake IV, to determine the effect of time of sampling. These data are presented along with a twenty-four hour study conducted during the same month on the same lake before modification (Figures III, IV, V, and VI). A comparison of these data shows that there is a much smaller variation in all of the components studied in the modified lake than was observed in the same playa the previous season. Diurnal fluctuations of dissolved oxygen are still as great within a given lake as among different lakes sampled at a given time (Figure IV).

For the water temperature studies thermistors will be placed in the lake at various locations along the shore line and in the open water area. Two stations will be located along the shore line, one about ten feet from the water edge, and the other about four inches below the water surface at that point. In the center of the lake a thermistor will be placed at the water surface, one at the one foot level, and another near the bottom. Thus five different stations will be sampled for variations in water temperature and continuously recorded on the chart.

Much more detailed information can be obtained during the coming season, but measurements with a conventional stem thermometer shows some interesting variations in surface temperatures. Table III presents observations on variations in water temperature along mosquito larvae sampling transects. The distance from shore, total per cent cover, water depth, and air temperature are also given. Temperature variations of 5-10° F were not uncommon from the shore line readings to the readings in the center of the lake. Differences up to 12° F were observed between air temperature and lowest water temperature reading on a given lake at a given time.

Along with these temperature observations it was also noted that more larvae were generally dipped in the warmer areas of the lake. With more detailed temperature data it will be desirable to make correlation and regression analysis of this temperature-mosquito number relationship. It may be necessary to consider the temperature factor in the modification of mosquito population sampling procedures.

The relationship of water temperature variations to air temperature variations over a twenty-four hour period are presented in Figure 2 for a modified and an unmodified playa. Observations on the unmodified playa, Lake V, Kitten, were made on September 21-22, 1962. The shore line water temperature was taken in 1" of water with 45% total cover, weed zone temperature was taken in 5" of water with 45% total cover located midway of the shore line and open water stations, and the open water temperature was taken in the center of the lake in 10" of water with 10% total cover. Lake IV, L. C. C., was studied on August 18-19, 1963, and the shore line station was 1/2" deep with 5% total cover, weed zone sample was taken in 6" of water with 45% total cover, and open water station was 18" deep with no emergent vegetation.

Visual evaluation of these data shows that there was much less variation in water temperature in the modified playa than was observed in the unmodified playa even though the air temperature fluctuated more and a shower was encountered during the study on the modified playa. Air temperatures varied from a high of 97° F to a low of 63° F and water temperatures varied from 86° F to 71° F on the modified playa. On the unmodified playa air temperatures ranged from 83.5° F to 63° F and water temperatures from 85° F to 64° F.

Points plotted on these graphs are actual temperatures at a given time and due to the time span between readings higher or lower temperatures might well have occurred. The primary factors contributing to the observed water temperature stability in the modified playa can probably be attributed to the larger volume and increased depth of water.



Table III Observations on water temperature variations along a mosquito larvae sampling transect on various lakes in relation to distance from shore, total % vegetative cover, water depth, and air temperature. Lubbock County, Texas. Summer 1962 and 1963.

| <u>Knowles Lake (II)</u> |              |             |                | <u>Cox Lake (IX)</u>       |              |             |                |
|--------------------------|--------------|-------------|----------------|----------------------------|--------------|-------------|----------------|
| Distance from shore      | %total cover | Water depth | Water temp. °F | Distance from shore        | %total cover | Water depth | Water temp. °F |
| 8-8-62                   |              |             |                | 8-8-62                     |              |             |                |
| 2"                       | 70           | 1/2"        | 88             | 1"                         | 75           | 1/4"        | 86             |
| 90'                      | 0            | 10"         | 85             | 30'                        | 80           | 2"          | 84             |
| 270'                     | 30           | 15"         | 83             | 60'                        | 13           | 7"          | 81             |
| Air temperature 92° F    |              |             |                | 120'                       | 10           | 19"         | 80             |
| 8-30-62                  |              |             |                | Air temperature 87° F      |              |             |                |
| 2"                       | 0            | 1/2"        | 85             | <u>Burgett Lake (VIII)</u> |              |             |                |
| 90'                      | 25           | 7"          | 78             | 9-20-62                    |              |             |                |
| 150'                     | 40           | 8"          | 78             | 3"                         | 18           | 1/2"        | 83             |
| 210'                     | 5            | 8"          | 79             | 30'                        | 30           | 7"          | 78             |
| Air temperature 92° F    |              |             |                | 60'                        | 15           | 10"         | 76             |
| 9-21-62                  |              |             |                | 120'                       | 15           | 11"         | 78             |
| 2"                       | 0            | 1/2"        | 83             | 180'                       | 15           | 13"         | 75             |
| 90'                      | 1            | 1-1/2"      | 85             | 420'                       | 8            | 14"         | 80             |
| 210'                     | 2            | 5"          | 81             | Air temperature 86° F      |              |             |                |
| 240'                     | 0            | 5"          | 82             | 11-12-62                   |              |             |                |
| Air temperature 87° F    |              |             |                | 30'                        | 0            | 1/4"        | 54             |
| 11-6-62                  |              |             |                | 90'                        | 1            | 1"          | 52             |
| 4"                       | 0            | 1/2"        | 69             | 180'                       | 0            | 4"          | 50             |
| 60'                      | 0            | 1"          | 67             | 240'                       | 1            | 4"          | 49-1/2         |
| 90'                      | 0            | 2"          | 66             | 270'                       | 0            | 4"          | 50             |
| 120'                     | 0            | 3"          | 65             | Air temperature 62° F      |              |             |                |
| Air temperature 72° F    |              |             |                | 11-2-62                    |              |             |                |
| 11-6-62                  |              |             |                | 2"                         | 2            | 1/4"        | 58             |
| 2"                       | 0            | 1/4"        | 72             | 30'                        | 2            | 1/2"        | 56             |
| 60'                      | 0            | 1"          | 68             | 60'                        | 2            | 1-1/2"      | 53             |
| 90'                      | 0            | 2-1/2"      | 67             | 90'                        | 3            | 3"          | 51             |
| 120'                     | 0            | 2"          | 66             | 150'                       | 0            | 5"          | 50             |
| 150'                     | 0            | 3"          | 66             | 270'                       | 0            | 6"          | 50             |
| 180'                     | 0            | 3"          | 66             | Air temperature 60° F      |              |             |                |
| 210'                     | 0            | 3"          | 66.5           | <u>Kittens Lake (IV)</u>   |              |             |                |
| Air temperature 74° F    |              |             |                | 8-14-62                    |              |             |                |
| <u>Kittens Lake (IV)</u> |              |             |                | 4"                         | 0            | 1/2"        | 95             |
| 9-12-62                  |              |             |                | 30'                        | 10           | 3"          | 89             |
| 2"                       | 75           | 1/2"        | 77             | 60'                        | 100          | 4"          | 72             |
| 60'                      | 60           | 10"         | 71             | 150'                       | 40           | 1-1/2"      | 78             |
| 120'                     | 35           | 13"         | 71             | 180'                       | 20           | 5"          | 79             |
| 270'                     | 10           | 16"         | 71             | 540'                       | 3            | 21-1/2"     | 78             |
| Air temperature 81° F    |              |             |                | Air temperature 83° F      |              |             |                |



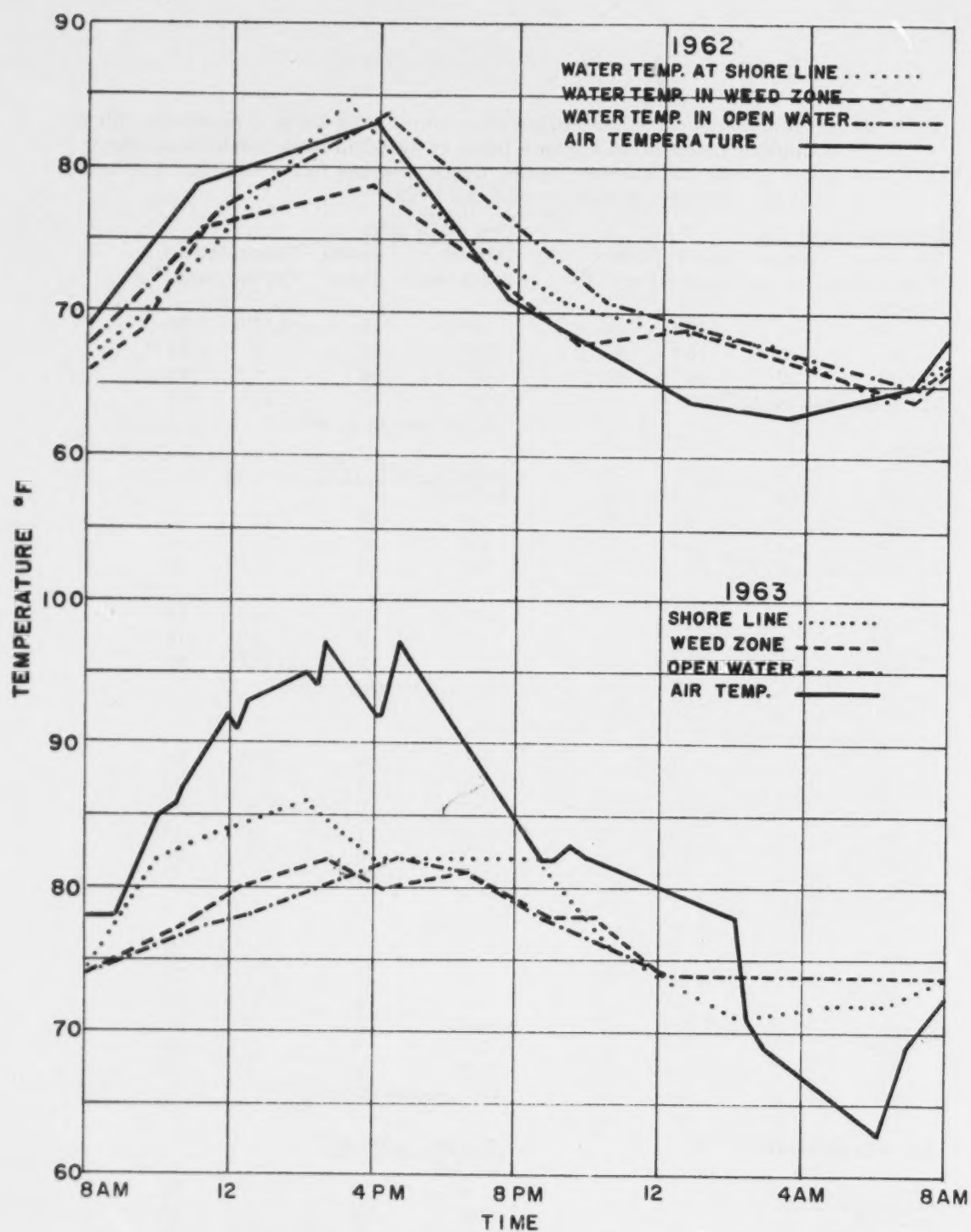


FIGURE 2. WATER TEMPERATURES IN THREE ECOLOGICAL ZONES ON A MODIFIED (LOWER GRAPH) AND AN UNMODIFIED (UPPER GRAPH) PLAYA IN RELATION TO AIR TEMPERATURES. OBSERVATIONS MADE OVER A 24 HOUR PERIOD ON LAKE V, SEPT. 21-22, 1962 AND LAKE IV, AUG. 28-29, 1963. LUBBOCK COUNTY, TEXAS

The diurnal fluctuations in alkalinity were greatly reduced in the modified playa. In 1962 the alkalinity varied from 35.68 to 70.80 ppm, while after modification in 1963 the content varied from 30.5 to 48.4 ppm. The pH of the unmodified playa varied from 7.8 to 9.8 and in the modified playa it varied from 7.2 to 9.00. In both instances these factors followed the same general trend before and after modifications, (Figure V).

Free carbon dioxide was not detected in the twenty-four hour study on Lake IV on August 17-18, 1962, but 3.5 ppm were found at 10:05 p. m. in the shore line sample in the August 28-29, 1963 study. The 1963 study is presented graphically with a study made September 21-22, 1962 on Lake V. Little relationship can be seen in these tests. The tables in Appendix IV show that free carbon dioxide was found in most of the lakes during the early part of the season, but none was detected on the later sampling dates. No free carbon dioxide was detected during or following rain recharge that occurred during the 1963 study; therefore rain recharge may not affect content as much as was first anticipated.

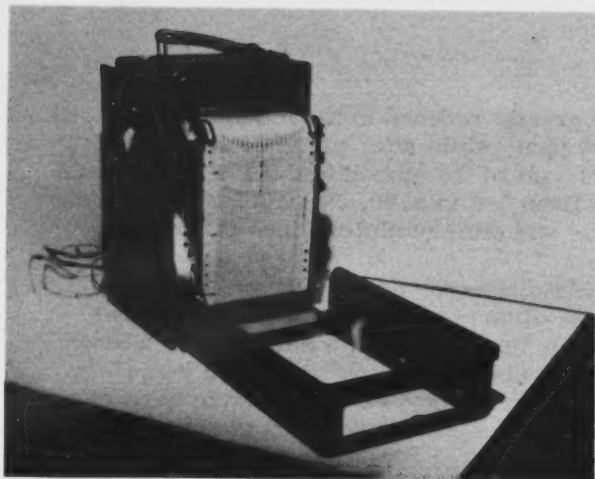
All analyses were conducted as outlined in Standard Methods for the Examination of Water and Waste Water, 11 th Ed. All chemicals used were supplied through the State Health Department and chemicals were replaced regularly.

Errata: All of the free carbon dioxide figures presented in parts per million in the first annual progress report need to be divided by ten to give the correct figures.

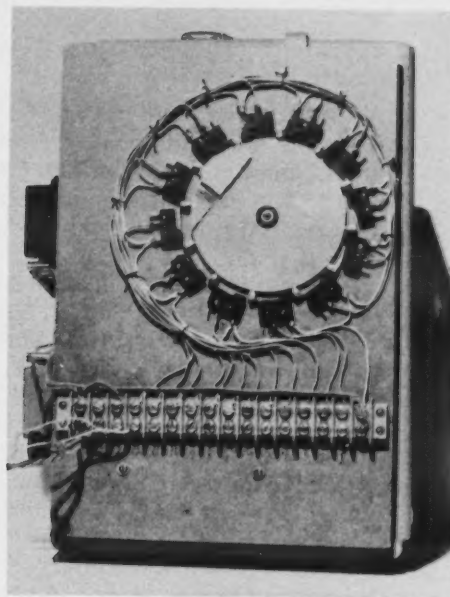
#### WATER TEMPERATURE STUDIES

Observations have been made during the past two season on the great variations that occur in the temperature of the water in a playa lake. All of these studies to date have been made while sampling for mosquito production or some other factor. A portable recorder is now being developed so that variations in water temperature as well as other factors can be continuously recorded over long periods of time. Some of the other factors this recorder will be used to study are air temperature, relative humidity, intensity and duration of rainfall, wind velocity and direction, and elevation of the water surface. It can be adapted to record any factor that can be reduced or converted into a measurable electrical impulse.

This portable recorder is being developed from a Model A 601C Esterline Angus Portable Recording D. C. Milliammeter (Plate 3). A series of twelve microswitches have been arranged in a circle on a piece of fiber board and attached to the case with the center of the fiber board and attached to the case with the center of the circle corresponding to the center of the chart drive shaft. A switching device was then attached to the chart drive shaft. The resulting arrangement of the switches and switching device are such that as the chart drive turns the chart, it also turns the switching device so that each switch is open for about four minutes each hour. Allowing one minute between switch depressions permits the recording of twelve factors per hour. If it becomes desirable more microswitches can be used by enlarging the circle, but the time factor soon becomes limiting and determines the maximum numbers that can be used. On the back of the recorder case another piece of fiber board was attached for the placement of resistors used in making the Wheatstone Bridge. In order to get a constant, steady voltage, mercury cells will be used to furnish the only small amount of electric current required. Thermistors will be used in the measurement of temperature changes. Details are being worked out on the devices to be used in measuring the other factors mentioned above.



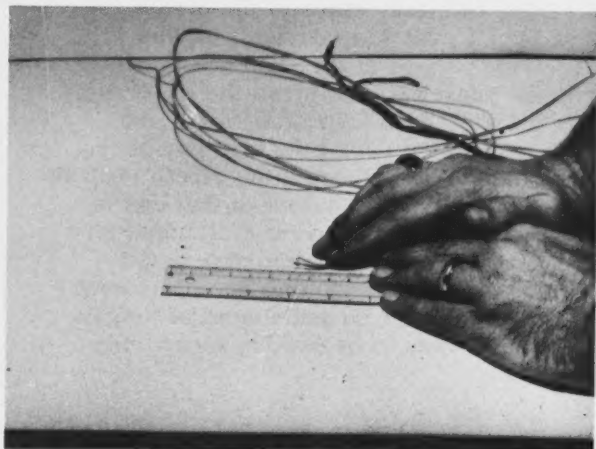
A



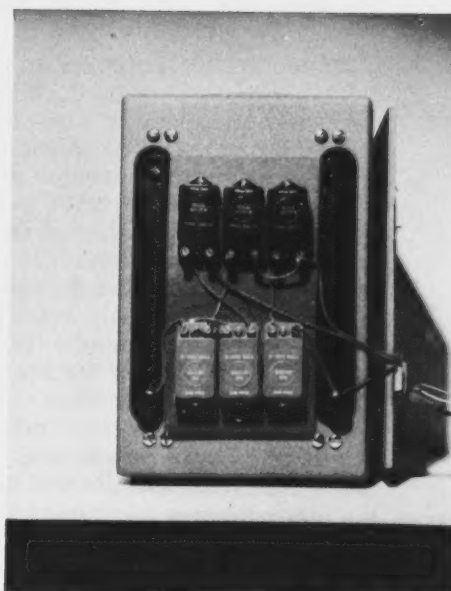
B

- A. GENERAL VIEW OF PORTABLE RECORDER
- B. DETAILED VIEW OF MICROSWITCH ARRANGEMENT
- C. CLOSEUP OF A THERMISTOR
- D. DETAILED VIEW OF RESISTOR PLACEMENT

C



D



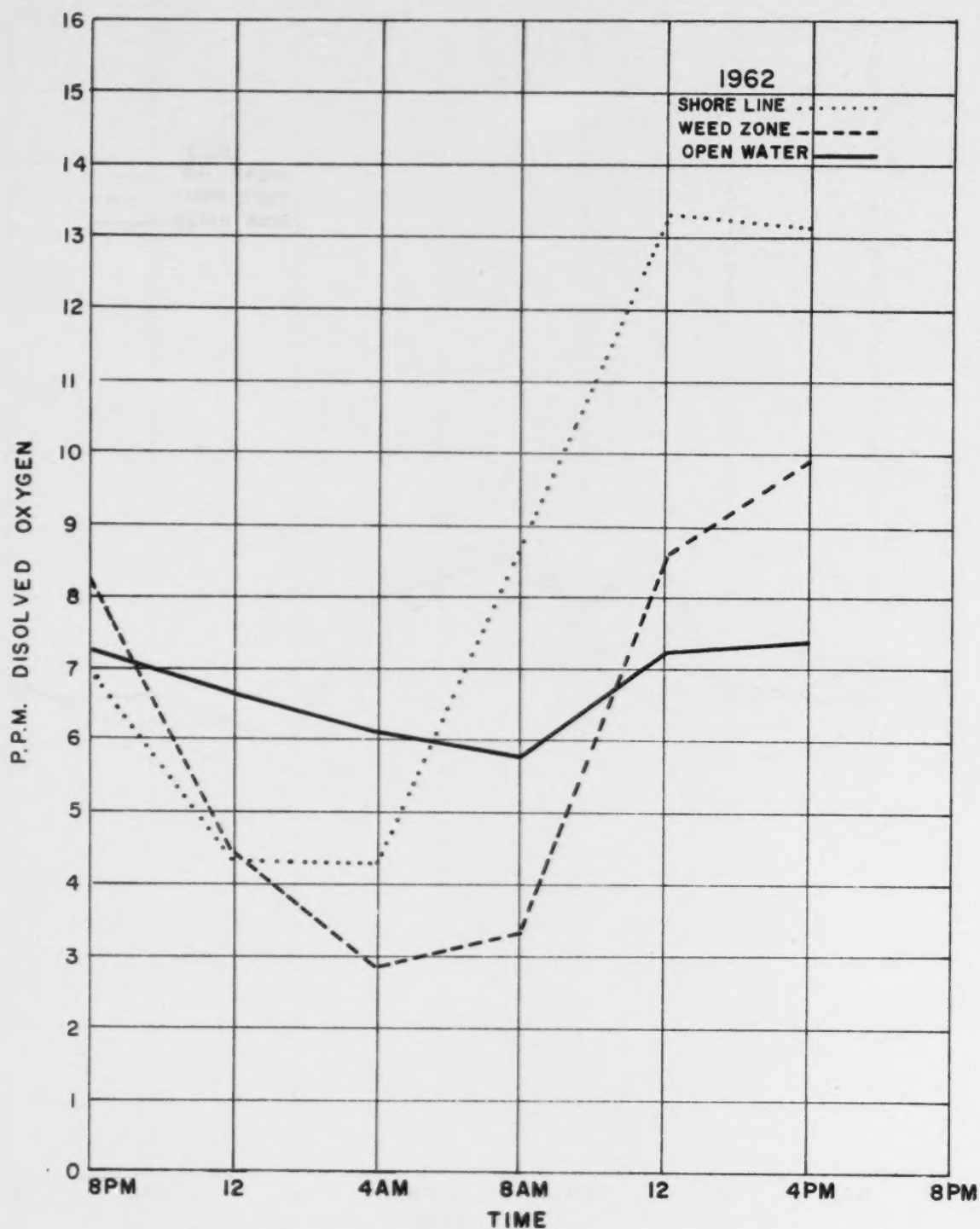


FIGURE 3. AVERAGES OF DUPLICATE ANALYSES FOR DISSOLVED OXYGEN TAKEN EVERY FOUR HOURS FOR A 24 HOUR PERIOD. SAMPLES WERE TAKEN FROM THE SHORE LINE, ZONE OF WEED GROWTH, AND OPEN WATER AUGUST 17-18, 1962. LAKE 4. LUBBOCK, TEXAS.



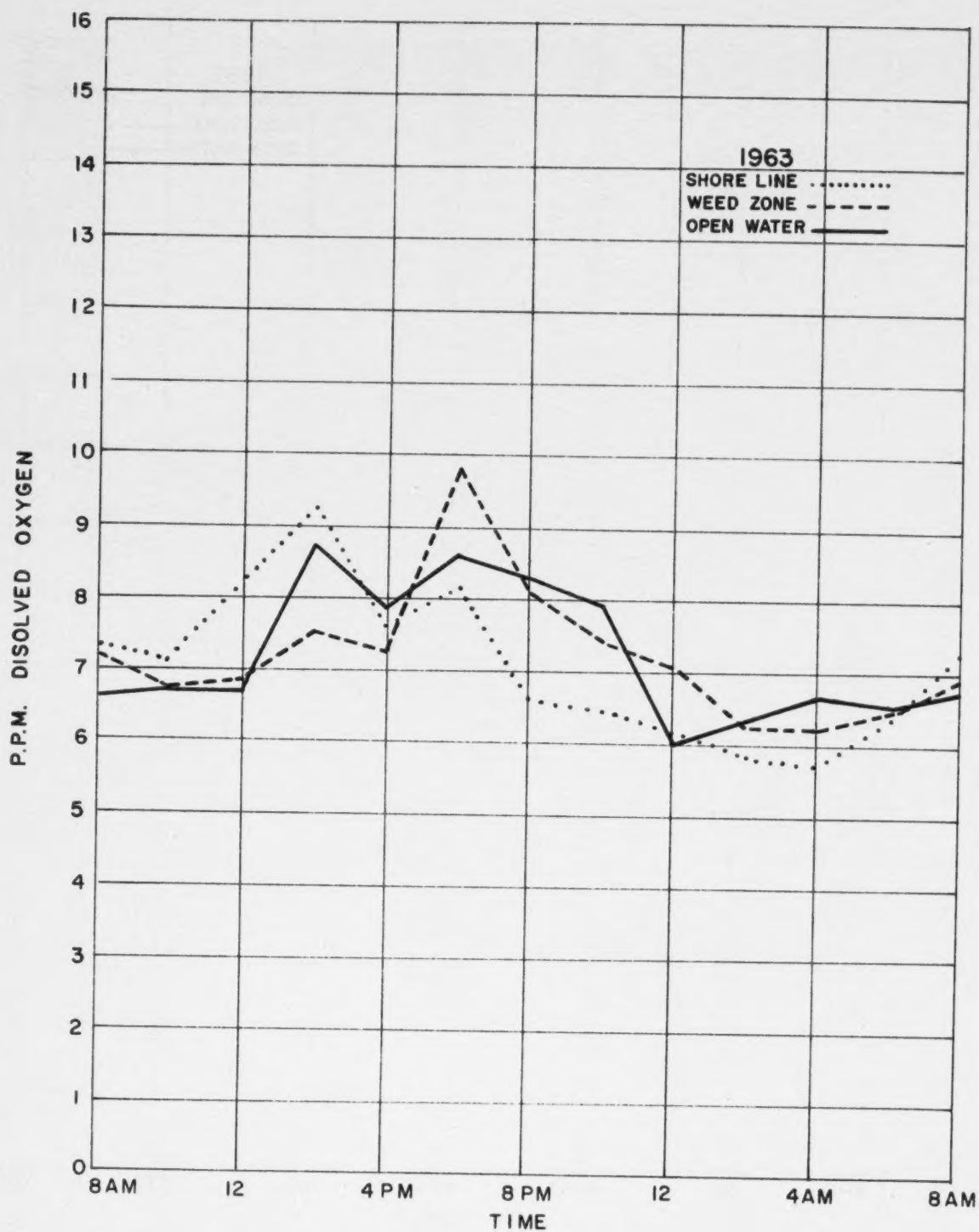


FIGURE 4. AVERAGES OF DUPLICATE ANALYSES FOR DISSOLVED OXYGEN TAKEN EVERY TWO HOURS FOR A 24 HOUR PERIOD. SAMPLES WERE TAKEN FROM THE SHORE LINE, ZONE OF WEED GROWTH AND OPEN WATER. AUGUST 28-29, 1963. LAKE 4. LUBBOCK, TEXAS

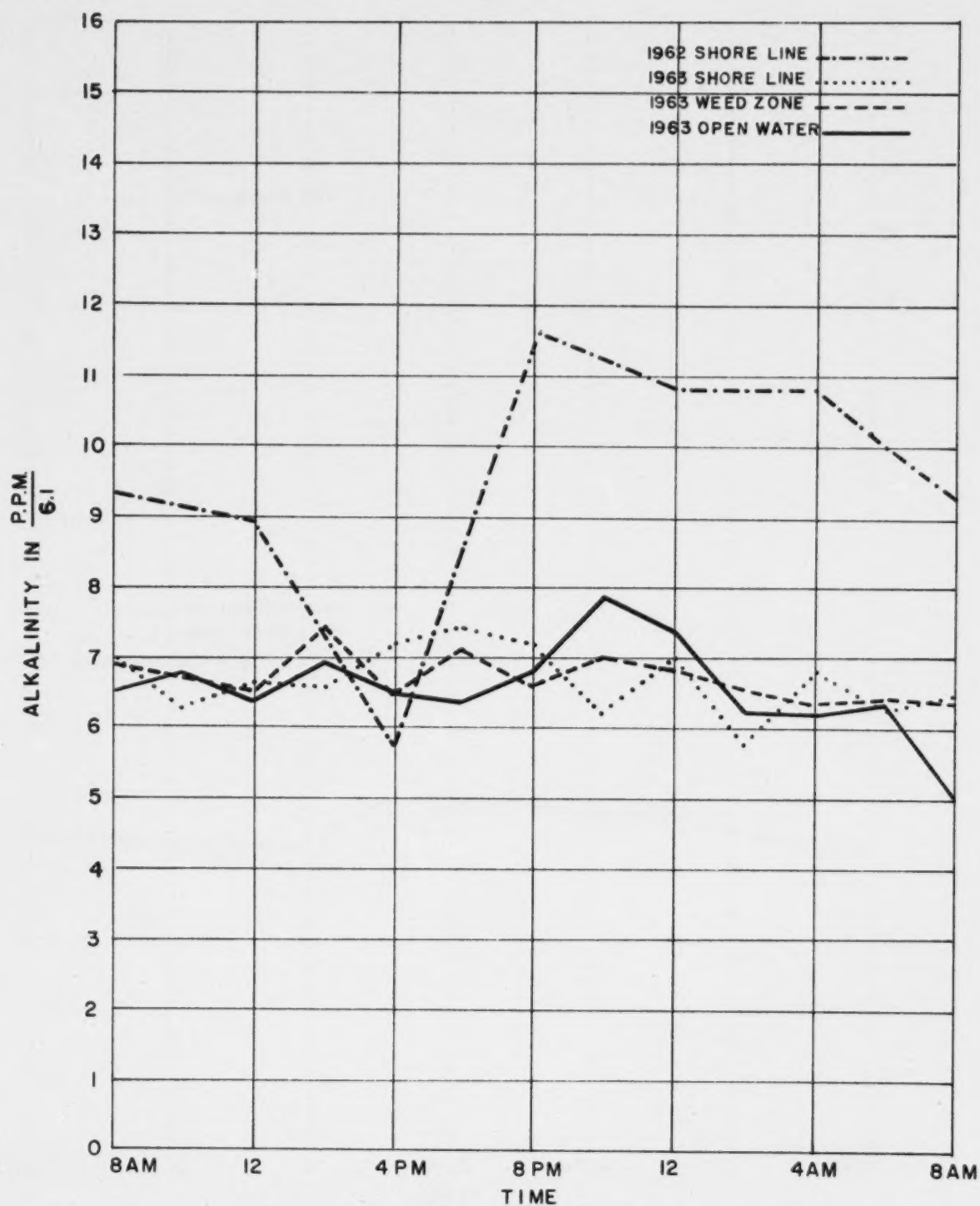


FIGURE 5. AVERAGES OF DUPLICATE ANALYSES FOR ALKALINITY TAKEN EVERY TWO HOURS FOR A 24 HOUR PERIOD ON A MODIFIED PLAYA IN RELATION TO ALKALINITY FOUND IN THE SHORE LINE SAMPLE OF THE SAME PLAYA BEFORE MODIFICATION (AUGUST 17-18, 1962). AUGUST 28-29, 1963. LAKE 4. LUBBOCK, TEXAS

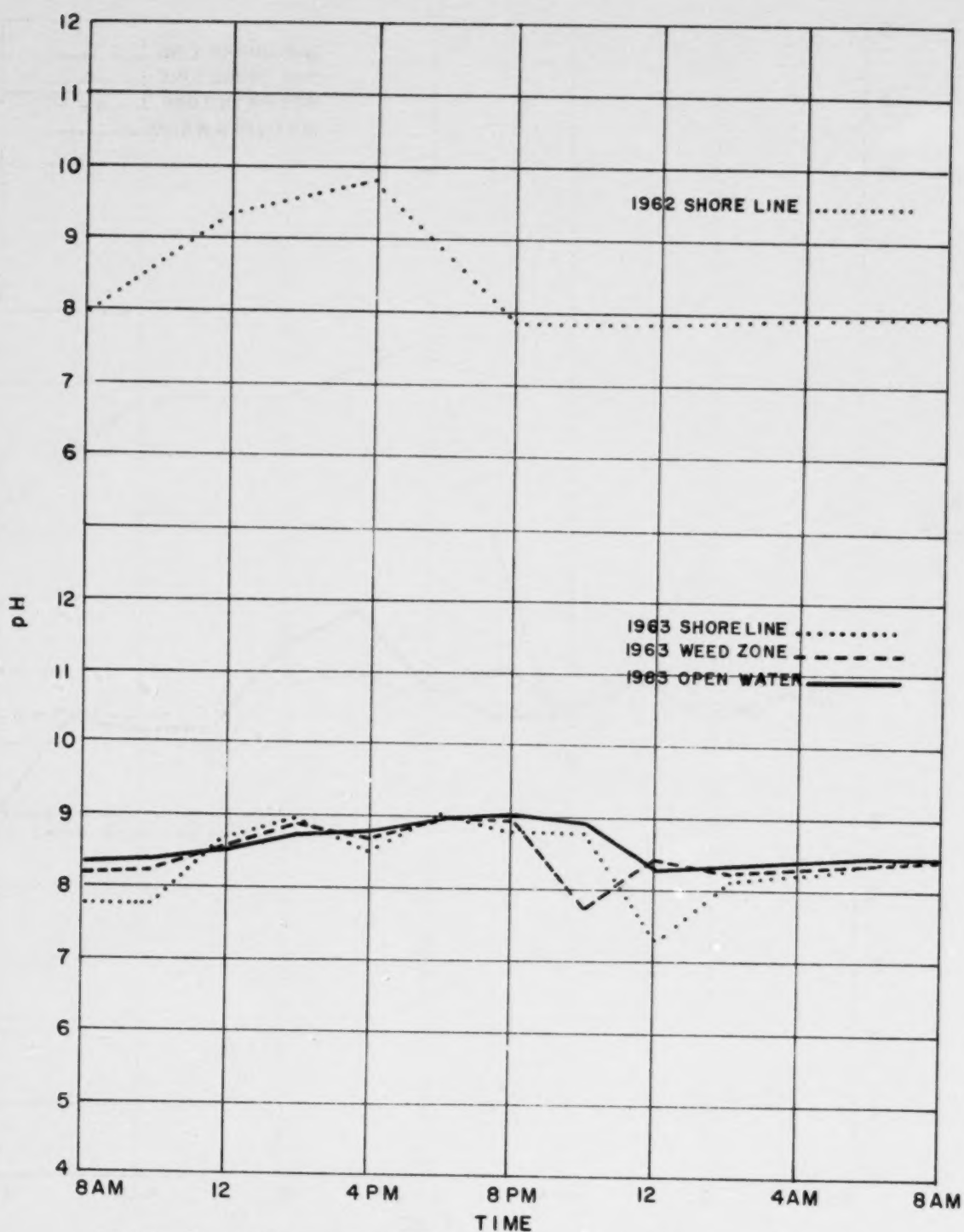
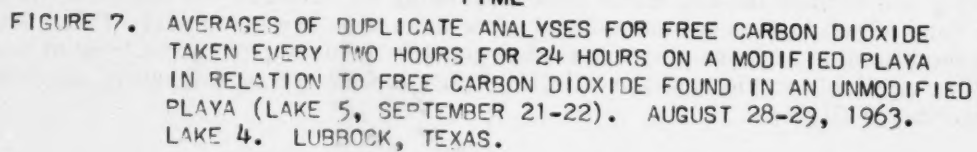


FIGURE 6. AVERAGES OF DUPLICATE ANALYSES FOR pH TAKEN EVERY TWO HOURS FOR A 24 HOUR PERIOD ON A MODIFIED PLAYA (LOWER GRAPH) IN RELATION TO pH FOUND IN THE SHORE LINE SAMPLE OF THE SAME PLAYA BEFORE MODIFICATION (AUGUST 17-18, 1962). AUGUST 28-29, 1963. LAKE 4. LUBBOCK, TEXAS





## PLANKTON STUDIES

Plankton studies have been made during the past two seasons with weekly samplings of the lakes. A modified Birge net of 125 mesh has been designed to operate in the turbid waters characteristically found in playa lakes, (D Plate 4). Each sample consists of material from a net drawn 20 feet at each of two sampling stations with one to two samples taken each sampling date. Samples are preserved in a formalin-alcohol solution for counting and identification. Samples were in the process of being analyzed at the time of publication and results will be presented in the thesis of the graduate student working on the biological phases of this project and a summary will be printed in the third annual progress report.

## WILDLIFE STUDIES

Wildlife utilization is one of the three main factors in this study that is to be considered in choosing the model modification. During the 1962 season, observations were made on the ten original playa lakes and a checklist of the species found frequenting them was presented in the first annual progress report of this project. During the 1963 season, observations were made on each of the study lakes at weekly intervals and the number of each species observed was recorded. Plans are being made to stock two of the lakes with game fish for study during the next season. Also, a survey was made of several landowners in an attempt to locate a playa lake that could be leased and included in the studies as a wildlife utilization study lake.

A survey of ten landowners showed that most of them have realized the value of the playa as a source of irrigation water, water for livestock, and as a source of wildlife for their own use. A summary of the findings shows that two lakes were used as a source of irrigation water and water for livestock, one lake was used only as a water source for livestock, three lakes were used as a source of irrigation water only, and two lakes were used as a source of water for wildlife and irrigation. The other two lakes were not considered useful as they were generally dry four out of five years (Table I, Appendix V).

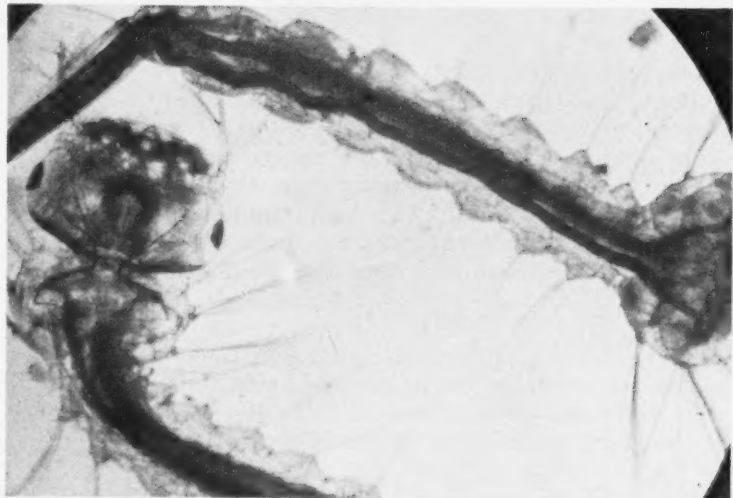
A summary of the data collected in the weekly observations made this season on species frequenting the ten study lakes is presented in Table II (Appendix V); giving the numbers observed on the four modified playas in one column and the numbers observed on the six unmodified playas in the other. Hufstedler Lake, one of those that has been modified, was found to have a large population of the leopard frog, Rana pipiens, from May to November. LCC Lake, another modified lake, had a large population of the yellow mud turtle, Kinosternon flavescens, during the same period. Essentially, the only difference in the modifications of these two lakes is that Hufstedler has a 4:1 side slope; whereas LCC has a 10:1 side slope.

During the 1962 season several Western hog-nosed snakes, Heterodon nasicus nasicus, were observed on the water shed of Burgett Lake; however, during the current season a total absence of this species was noted in spite of the large toad population during both seasons.

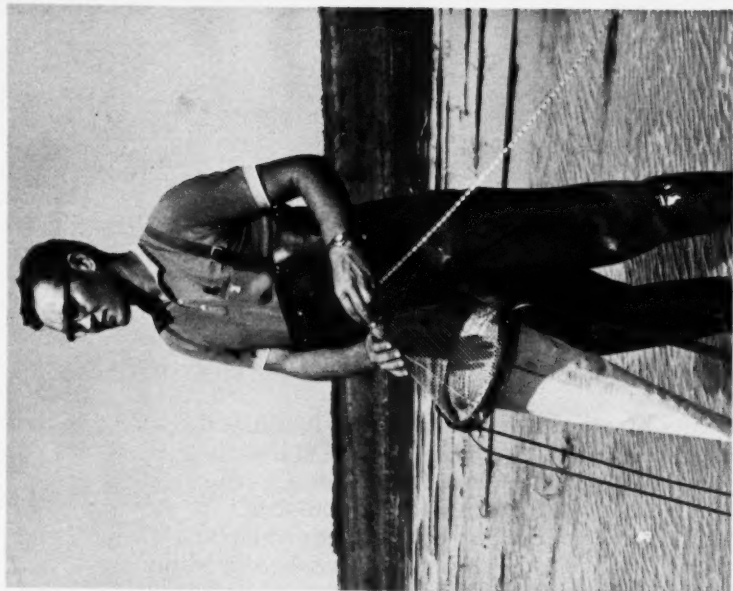
Numbers of wading birds and shore birds observed were approximately equal during both seasons; appearing in large numbers as the water level of the lakes decreased. Diving and surface feeding ducks were still being observed on the modified lakes at the time of publication but unmodified lakes have been dry since early Fall. Therefore, the modification of these playa lakes has provided a more permanent body of water that will be available to the resident wildlife population as well as migratory waterfowl in their annual flights.



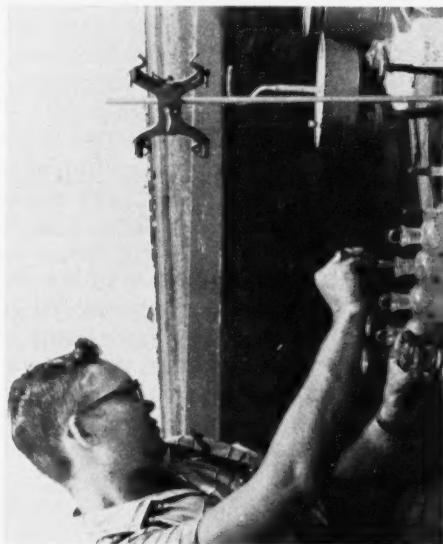
A. PLANKTON IDENTIFICATION



C. MOSQUITO LARVAE MAGNIFIED



D. PLANKTON NET



B. WATER CHEMISTRY TECHNIQUE



F. VEGETATIVE PLOT



E. SWEEP NET

PLATE 4

Field and Laboratory Studies

## VEGETATIVE STUDIES

The flora associated with natural playas has been surveyed and a check list of the species that have been identified was presented in the first report. Additional plants have been collected, but have not been positively identified at this time. Soil samples were taken on the fill area of the modified lakes and analyses conducted by the soil scientists at the State Agricultural Experiment Station show an extremely low nitrogen and organic matter content (Table III, Appendix V). With these deficiencies in mind, studies were initiated on two of the modified lakes to study revegetation patterns.

Beginning on June 12, 1963, quadrant plots of one square yard were staked at the water's edge each week. The plots were located on the northeast side of Hufstedler Lake and on the northwest side of LCC Lake. All of the plots were counted for new plant growth at each date and all plants having its main stalk inside the quadrant were counted. Seven plots were destroyed in farm operations by the farm owners and as a result data are not as complete as it could be. Also, as would be expected, rains that occurred later in the season caused some of the plots to be inundated and resulted in the loss of vegetation in those plots.

A summary of the data collected from plots on Lake IV, LCC, shows that 372 plants were counted on the seven quadrant plots, this figure includes repeat counts made on some plants. Of these 327 plants counted 41% were ragweed, Artemesia gnaphaloides; 27% were barnyard grass, Echinochloa crus galli; and the remaining 32% were annual weeds of which 4% were carpetweeds, Mollugo verticillata. On Lake III, Hufstedler, a total number of 178 plants were counted on the four plots studied. Of these 87% were annuals and pigweed, Ameranthus retroflexus, was the dominant one, the remaining 13% were made up of 10% barnyard grass, 2% were ragweed; and the other 1% has not been identified.

Following heavy rain recharge and inundation of the quadrant plots on LCC, most of the annuals were destroyed and as the water receded the dominant plant was ragweed. Pigweed was the dominant plant on two unmodified playas—Lake I, Huckabee; and Lake VI, Holland—both of which were frequently cultivated. Pigweed was also dominant on the two modified lakes studied.

Most of the study lakes varied from the growth patterns observed during the previous season. Lake X, Reese, followed the same pattern with wild onions, Nothoscordium bivalve, being the dominant plant in the spring and then gradually changing until rush, Eleocharis spp. became the dominant one in the summer months. Arrowhead, Sagittaria longiloba and smartweed, Polygonum lapthifolium, were the dominant species during both seasons on Lake II, Knowles. During the 1962 season Lake VIII, Burgett, had abundant vegetation and the list of plants included smartweed, arrowhead rush, ragweed, knotweed (Polygonum aviculare), and several other plants. However, this season the vegetation was very sparse in the lake bed and this reduction is attributed to the extremely deep waters up to 8 feet in depth. Lake IV, Kitten, had about the same vegetative pattern for both seasons on the unmodified side, but due to the modification being completed late in the year the fill area was relatively barren. Lake IX, Cox, had smartweed and barnyard grass as the dominant plants during both seasons. Lake XI, Krueger, was completely covered by smartweed during the previous season but high water limited the vegetative growth during the current season to a few aquatic plants including Marsilea spp. which was the dominant one.



Vegatative studies are made on each lake on each date they are sampled for mosquito larvae production. At each dipping station the total percent of water covered by vegetation is recorded along with the percent covered by broadleaf weeds and the percent covered by grass, with the species of plants listed when known. Correlation and regression analysis of this data will be made at a future date.



# Part II

## ECONOMIC EVALUATION AND LAND USE STUDIES

Conducted and written by

James W. Graves, David G. Moorman and Dr. Willard F. Williams

Department of Agricultural Economics,

Texas Technological College

TEXAS TECHNOLOGICAL COLLEGE

Lubbock, Texas

ABSTRACT OF THESIS

for the degree of

MASTER OF SCIENCE IN AGRICULTURE

AN ECONOMIC EVALUATION OF PLAYA LAKE  
RESOURCES IN LUBBOCK COUNTY, TEXAS

By David Garner Moorman

The playa lakes of the Texas High Plains generally have not been included among the area's agricultural resources. Negative values were assigned so long as abundant land and water resources were available in the area. But with sharply rising land values and rapid depletion of available underground water supplies, the playa lakes have been given more consideration as sources of supplemental irrigation water and of added crop acres.

Potential contributions of the playa lakes to farm income in these uses are evaluated in this initial, introductory economic study. The analysis involved: (1) consideration of the origin, physical characteristics, and problems associated with playa lakes; (2) description and evaluation of present playa lake uses, cultural and management practices, and economic value; and (3) detailed analyses, through application of the budgeting technique, of potential costs, returns, and net returns associated with specified plans for use of playa lake land and water. The principal objective was to provide farmers with the information required for intelligent and rational decisions consistent with more efficient use of playa lake resources. The study suggests that while little use presently is being made of the playa lakes, they can be used economically in farming operations. In addition, agricultural use of the playa lakes will reduce the cost to society from flooding, the nuisance associated with a higher insect population, and disease.

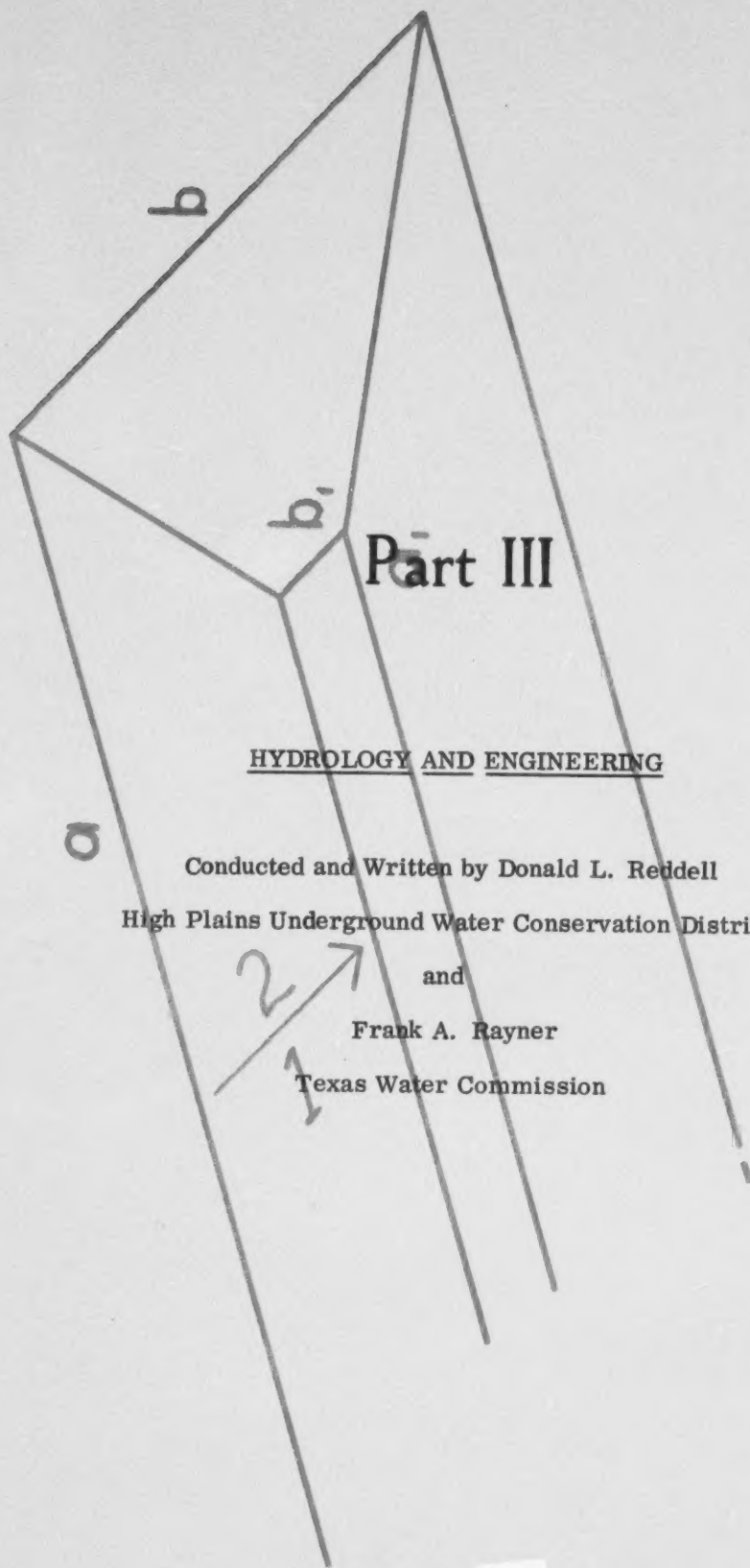
Three agricultural enterprise plans were evaluated in this economic study. Enterprise I dealt with the growing of fifteen acres of wheat -- the current government acreage allotment -- in a playa lakebed. This enterprise was set up for use in relatively small, dry lakes which suffered only low losses from flooding. In Enterprise II, the playa lake was hypothetically modified and the water used to irrigate cotton planted near the lake. Enterprise III involved a multipurpose use plan in which a playa lake was theoretically modified and used for irrigation water, crop production, and elimination of the local mosquito problem. A cost return study was made in each enterprise.

Net income from wheat in Enterprise I was greater than with cotton in Enterprise II or with multipurpose use in Enterprise III. However, such a direct comparison can be made only within rather narrow limits. Each enterprise involved a specific set of conditions which included specified lake characteristics. Enterprise I primarily used the land resource, and Enterprise II used the water resource which accumulated in the lake.

In general, playa lakes which held water were used in development of data for Enterprise II, and Enterprise I was adapted for use with lakes which usually did not hold water. In addition, alterations in the economic or institutional environment such as a change in governmental programs would have a changing effect upon returns from wheat or cotton.

The cost associated with modification, equipment and other resources necessary for Enterprise III were high relative to Enterprise I and II. In addition, certain social benefits were not included among the returns. A favorable net income, nevertheless, was indicated under conditions specified for entrepreneurs in adopting Enterprise III. It was clear, however, that features of the lake along with costs and prices likely would determine the enterprise selection -- the enterprise which contributed most to farm income is the one that generally would be selected by farmers irrespective of whether or not this selection made any net contribution to social benefits.

The study was exploratory in nature. Additional research is needed to (1) determine other profitable enterprises which would use lake resources (land and water), and (2) examine cost and income possibilities associated with all relevant alternatives. Development of more complete data and the use of linear programming in an economic marginal analysis of playa basins would provide more complete, more useful, and more definitive findings. Additional research would make possible more accurate measurements of the potential benefits, including social benefits, offered by extended or modified use of playa lakes in the Texas High Plains area.



# Part III

## HYDROLOGY AND ENGINEERING

Conducted and Written by Donald L. Reddell  
 High Plains Underground Water Conservation District  
 and  
 Frank A. Rayner  
 Texas Water Commission

$$V = \frac{1}{6} h [(2a + a')b + (2a' + a)b']$$



## HYDROLOGY AND ENGINEERING

### INTRODUCTION

This is the second annual progress report covering the hydrology and engineering phases of Project 29, Division of Water Supply and Pollution Control, USPHS, for the period from September 1, 1962 through August 31, 1963. The purpose of this section (Part III) is to briefly present the results of the engineering and hydrological data collection activities of the 1962-63 study year.

Only those conclusions and recommendations believed necessary to the more efficient collection and analysis of data, and the completion of the projected engineering activities during the coming study year, are presented in this report.

### TOPOGRAPHY

#### Mapping of Lakes

Lake No. 11 (J. Krueger) was the only previously unmapped lake that was surveyed during this study year. A topographic map for Lake No. 11 is presented in Appendix I.

Lakes 3, (Hufstedler), 4 (Lubbock Christian College) and 5 (Kitten) were resurveyed, and new topographic maps prepared. These lakes were "modified" (see later text) during the year, necessitating resurveying and the calculation of their new area and volume characteristics. The new maps (after modification) as well as the old maps (before modification), for these lakes, are presented in Appendix I. All maps completed for this study are drawn to the scale of 1 inch = 100 feet. The maps in Appendix I are reduced scale copies.

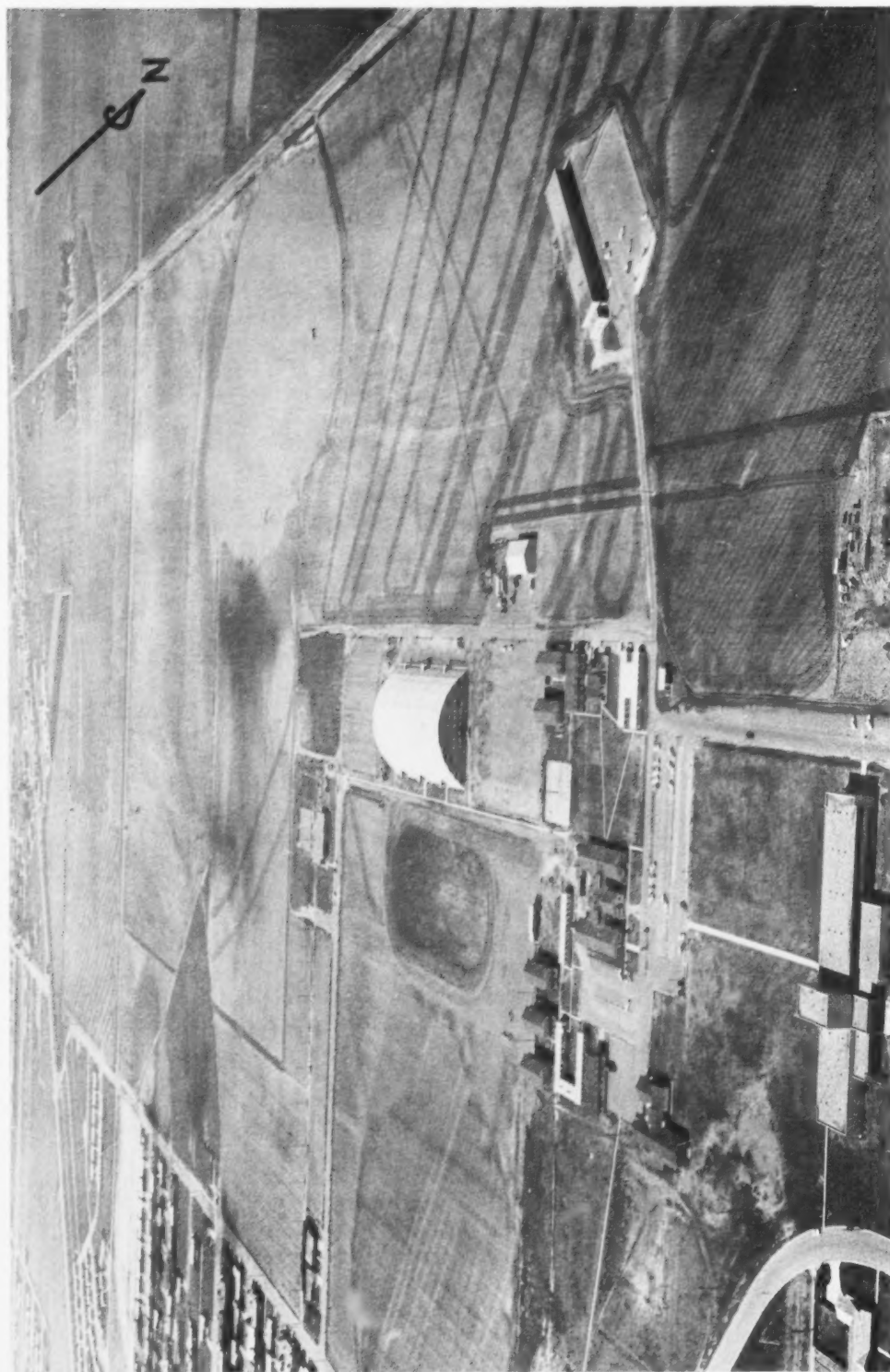
Plate 1 consists of an aerial and panoramic view of Lake No. 4. The aerial photograph was taken after the rain of June 1, 1963. The panoramic photograph was taken during January of 1964. This photograph caught two young anglers trying out their new casting rods.

Plate 2 consists of an aerial and panoramic photograph of Lake No. 5. The aerial photograph was taken after the rains of May 22, 1963 (see later text and Appendix II). The lake pit, shown on this photograph, had not been completed at the time this photograph was taken. The panoramic view shows the Kitten lake pit under construction. This photograph was taken in August of 1963.

An aerial view of the Hufstedler lake and pit (then under construction) with its accompanying topographic map, is presented on the front cover of this report. This lake, after the rains of June 1, 1963, is shown on the back cover.

#### Elevation-Area and Elevation-Volume Curves

Elevation-volume and elevation-area (rating) curves were constructed for Lake No. 11 (J. Krueger). These curves are presented in Appendix I. Rating curves were also made for the modified lakes, Nos. 3 (Hufstedler), 4 (Lubbock Christian College), and 5 (Kitten). These curves along with the rating curves constructed for these lakes

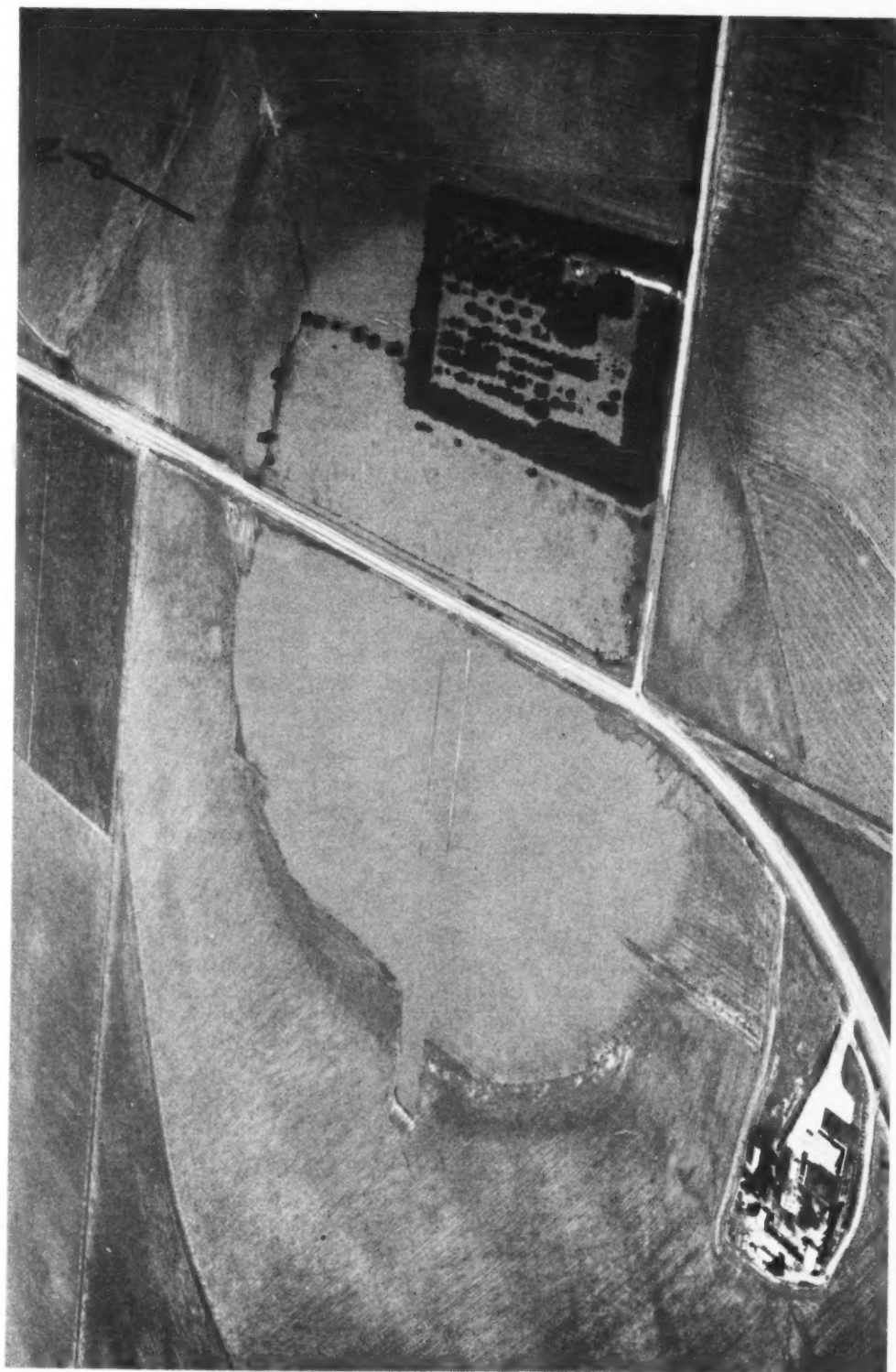


2.3



LAKE NO. 4, LUBBOCK CHRISTIAN COLLEGE

PLATE 1



3, 3

N 4 —



PLATE 2

LAKE NO. 5, C. K. and WM. KITTEN



during the 1961-62 study year (prior to modification) are presented in Appendix I.

By blocking the lone culvert beneath Highway 41, (see Appendix I) Lake No. 5 can be effectively separated into eastern and western portions.

This separation necessitated the construction of rating curves for each of the lakes thus created. However, if flow through the culvert is not obstructed, and in any event should the water surface reach an elevation above 48.6 feet, when water would flow across Highway 41, the eastern and western portions would be united creating one lake. In this event, the third rating curve, considering Lake No. 5 as one unit, would be consulted for area and volume determinations. This third curve, the combined lake curve, is similar to the one rating curve constructed for Lake No. 5 during the 1961-62 study year.

The end-area formula (discussed in the First Annual Progress Report, Page 26), with modifications, was used to determine volumetric values for Lakes Nos. 4 and 11; and the unmodified portions of Lakes 3 and 5. The volumetric formulas, with modifications, for the wedge and obelisk were used in making volumetric determinations of the Hufstedler (Lake No. 3) and Kitten (Lake No. 5) pits.

#### EQUIPMENT USED TO COLLECT HYDROLOGICAL DATA

##### Rain Gages

Rain gages consisting of a 5/8-inch glass tube set in a 5 3/4-inch graduated metal container were used to measure rainfall at all of the study lakes. This gage is non-recording, and necessitates frequent field inspection.

The rainfall records at lakes 1 through 6 and 8 through 11 for the study year 1962-63, are presented as histograms on the even numbered Figures in Appendix II. These records were compiled from readings made from the rain gages heretofore described. Therefore, the time of rainfall occurrence, as recorded, may contain minor errors, however, the amounts, as recorded, are assumed to be in the correct order of magnitude.

A Leupold Stevens A 35 automatic water level recorder and a Tilting Bucket Rain Gage have been purchased. The A 35 recorder is adaptable to a number of different time and gage scales. This recorder is also fitted to automatically record rainfall on the same chart used to record water levels. This recorder and rain gage combination will provide for the accurate measurement of the intensity and duration of rainfall and the resultant changes in water levels (see Plate 3, Picture 6).

##### Staff Gages

Staff gages of the type shown on Plate 4, Pictures 1 and 2, have been installed in Lakes 1 through 6 and 9 through 11. Lakes 3 and 4 have two such gages each. In those lakes wherein staff gages had been removed to provide for modification, or wherein staff gages had not yet been installed, water level measurements were sometimes made with a dated stake (see Plate 3, Pictures 1 and 2). Such stakes were later relevelled to their respective elevations by being "tied-in" (by level or transit) to the respective lake's bench mark.





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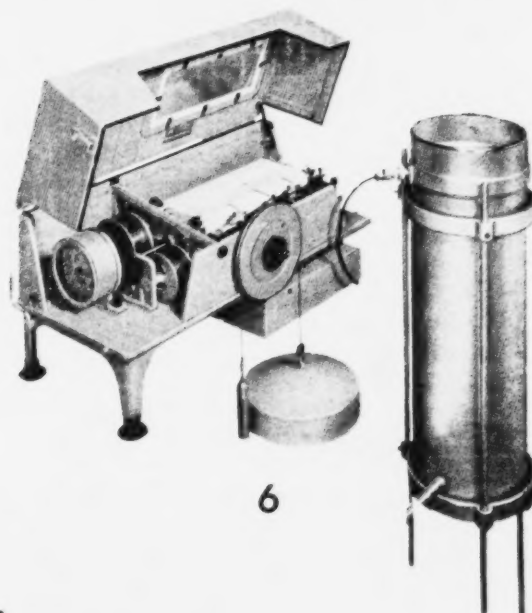
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PLATE 3

5. 3

Staff Gages, being non-recording (except for flood trash, see Plate 4, Picture 1), require frequent visits to the lakes. This type of gage is subject to storm and ice damage when not properly supported. The staff gage shown on Plate 4, Pictures 1 and 2, although backed by a 1/4-inch steel strap, has been bent above the juncture with its 4-inch by 4-inch wooden supporting post.

The staff gages presently in use require (for the most part) optical magnification for reading. Trash, mud staining and algal growth render them even more difficult to read. During the coming study year, other adaptations (graduations painted on recorder towers, stadia boards, etc.) are expected to be employed in an effort to develop a better staff gage system for the lake conditions encountered on this Project.

#### Automatic Water Level Recorders

At the onset of this study, the Texas Water Commission loaned three Leupold Stevens Type F and two Leupold Stevens Type FM automatic water level recorders to the Project. These recorders have proven highly adaptable to this type of study.

During the summer of 1963, five Leupold Stevens Type F (with solenoid clock) recorders and one Leupold Stevens A 35 recorder, with Tilting Bucket Rain Gage were purchased. The Type F recorder, with the solenoid clock, is identical to the Type F and Type FM Recorders described in the First Annual Progress Report (pages 28, 29 and 30), with the added advantage of the adaptability to a larger range of time scales.

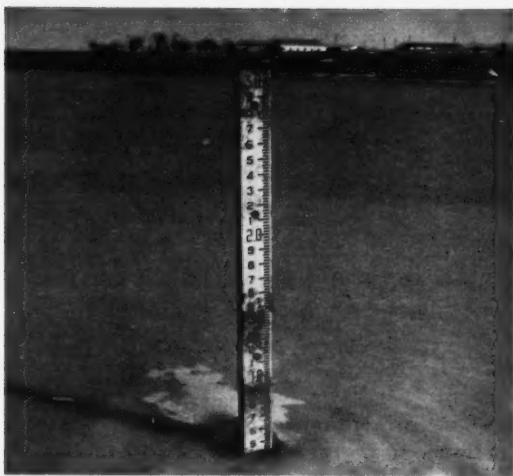
The A 35 Recorder, in addition to being adaptable to several time and gage scales, was selected primarily because it is the only water level recorder capable of simultaneously recording rainfall (see Plate 3, Picture 6). This recorder can also be adapted to record temperature, however, the Thermograph was not purchased.

At the end of the 1962-63 study year, a total of eleven automatic water level recorders were available to the Project. Present plans call for the automatic recording of water levels in Lakes 1 through 6 and 8 through 11 during the coming study year.

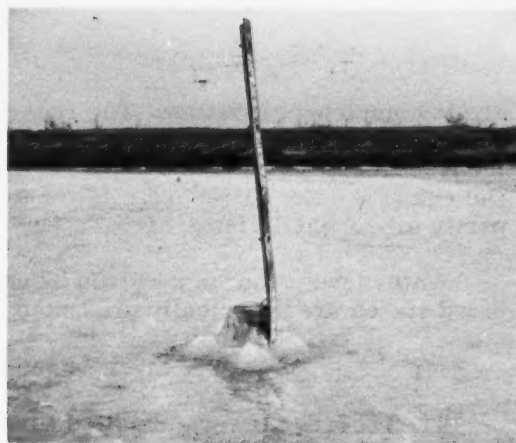
Two automatic water level recorders are scheduled to be installed in the Kitten and/or Lubbock Christian College lakes. These recorders, operating from a common float will be so geared to provide for the measurement of short term water level rises (during the filling of the pit) and also to provide for long term water level monitoring. These dual records will be provided by a modified Type F (with solenoid clock) recorder coupled with another Type F (with solenoid Clock) or Type FM recorder. In a dual recorder installation, a Type F (with solenoid clock) recorder will be fitted with a pencil scribe instead of the standard inking stylus (see automatic water level recorder section of the First Annual Progress Report). The clock of this modified short term recorder will be activated by a mercury switch, tripped by the recorder drum at the first rise of the float.

Other adjustable modifications will have to be made to the float and counterbalance weight system.

The A 35 recorder and its Tilting Bucket Rain Gage is scheduled to be installed in Lake No. 8 (Burgett). This relatively small lake and its equally small drainage area



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PLATE 4

LAKE NO. 3, E. K. HUFSTEDLER

7.3



are in complete cultivation. The records supplied by this A 35 recorder installation is expected to provide rainfall-runoff data under agricultural conditions. At a later date, the A 35 recorder and attached rain gage could be installed in the Lubbock Christian College (Lake No. 4) recorder tower to monitor the rainfall-runoff relationship in a partly urbanized drainage area.

Water level records provided by automatic recorders, staff gage readings and dated stakes are graphically presented in the even numbered Figures of Appendix II.

#### Recorder Towers

The recorder towers installed during the 1962-63 study year are, with slight modifications, identical in design and construction to those towers described in the First Annual Progress Report (Pages 30-32).

A 17-foot, 12-inch (ID), 1/4-inch wall, steel casing, tower was assembled for installation in the Hufstедler lake pit. This tower was to be served by a 48-foot, wooden framed, steel-matted catwalk. However, the rains of May 22 interrupted the construction of the catwalk assembly, floating out one 16-foot section of the catwalk and its 4-inch (diameter) wooden column (see Plate 5, Pictures 1, 2 and 3).

The 7-foot 6-inch tower, removed from this lake during modification, was strapped to the remaining catwalk assembly to provide for the temporary housing of the automatic water level recorder (see Plate 5, Pictures 2, 3, 4, and 5). At the time of this writing, the lake level has receded below the base of this temporary installation (see Plate 5, Pictures 3, 4 and 5).

The construction of the recorder tower assembly in Lake No. 4 (Lubbock Christian College) is described by Plate 6 and illustrated by Plate 7. The location of the tower assembly is shown on this lake's topographic map (Appendix I). This map also shows the back fill providing access to the shore end of the catwalk assembly.

The tower installation in the Kitten Lake (Lake No. 5) consists of a 21-foot 1-inch (above ground), 12-inch (ID), 1/4-inch wall, steel casing (see Plate 8, Pictures 1 through 5). This tower is set on a 3-inch concrete sub-foundation 6 inches below the base of the pit. The lowermost 6 inches of the casing is filled with cement and a 16-inch (diameter) concrete foundation was poured around the base of the tower. Two 1-inch by 1/4-inch channels, 3 feet long, are set in concrete and bolted to the casing (see Plate 9, Picture 1). A 6-inch by 8-inch opening covered by a snug fitting door provides access to the base of the tower.

A 40-foot wooden frame, steel grated catwalk provides access to the tower head and recorder housing (see Plate 8, Pictures 1 through 5 and Plate 10, Pictures 1, 2, 4, 5 and 6). The catwalk assembly is supported by creosoted poles, 4 inches in diameter, set in about 3 feet of concrete.

Guy wires stabilize the catwalk and tower assembly (see Plate 8, Pictures 3 and 5; Plate 9, Picture 2; and Plate 10, Pictures 4 and 5). This tower is provided with a removable recorder housing assembly (see Plate 10, Pictures 2 and 3). All recorder towers will eventually be modified to provide for the interchangeability of recorder housing assemblies.





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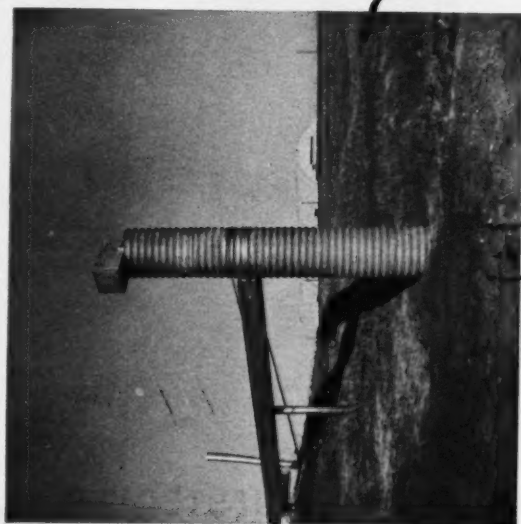
PLATE 5

LAKE NO. 3, E. K. HUFSTEDLER

9.3

# PLATE 6

RECORDER TOWER, LAKE NO. 4,  
LUBBOCK CHRISTIAN COLLEGE



LAND SURFACE

RECORDER FLOAT

WATER SURFACE

22'X18" 16 GAGE STEEL PIPE, WITH  
A 1'X15" SECTION, CENTERED (WELDED)  
AT ABOUT 3 1/2' FROM THE LOWER  
END

60'X15" (ID), RUBBER GASKET, CONCRETE PIPE

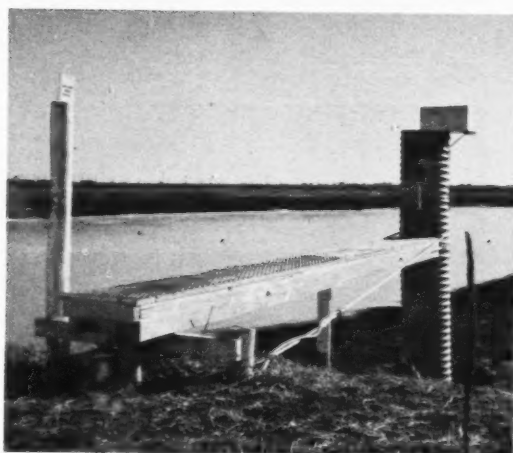
CONCRETE



1



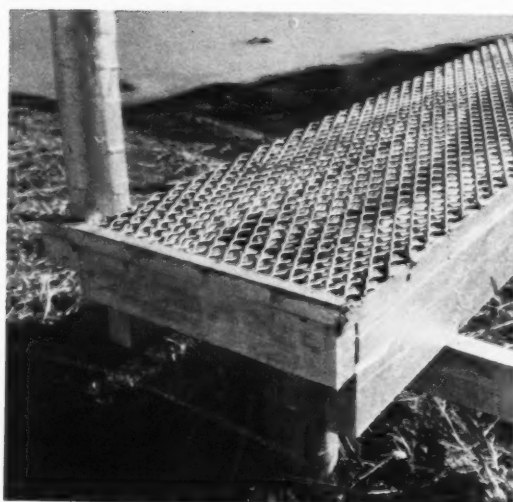
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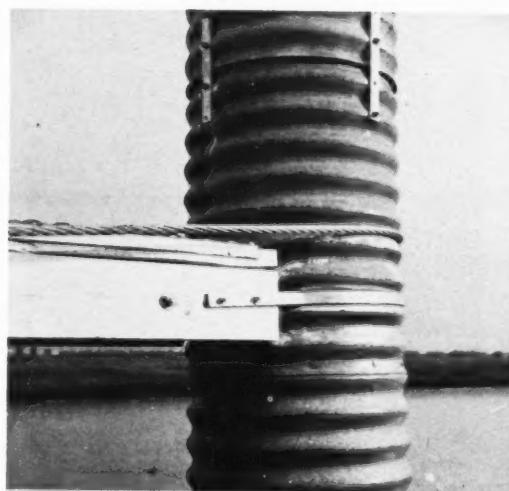
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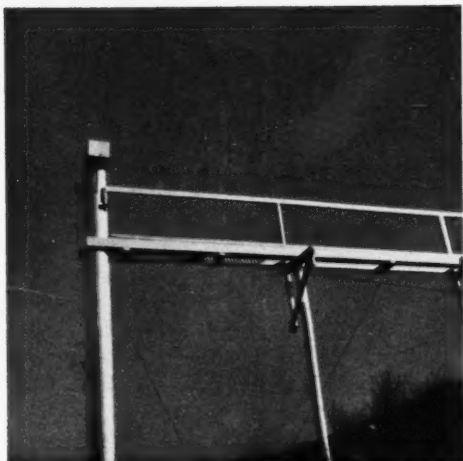
PLATE 7 LAKE NO. 4, LUBBOCK CHRISTIAN COLLEGE



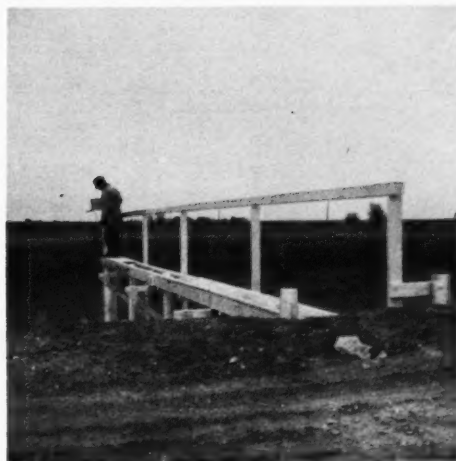
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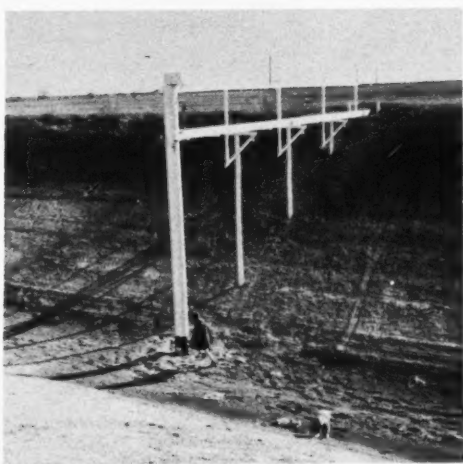
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PLATE 8

LAKE NO. 5, C. K. and WM. KITTEN

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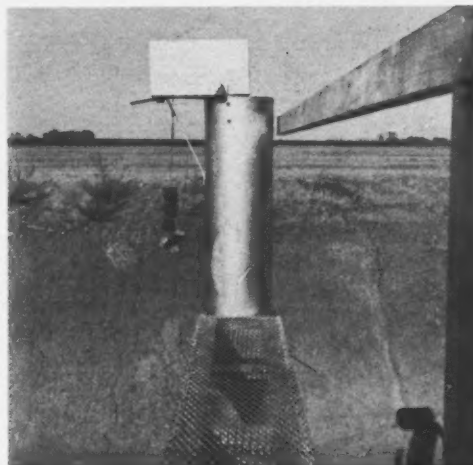
PLATE 9

LAKE NO. 5, C. K. and WM. KITTEN

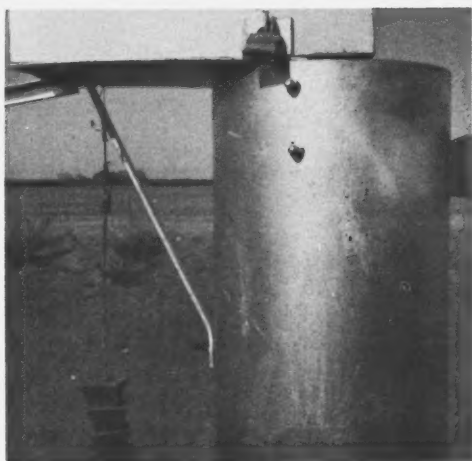
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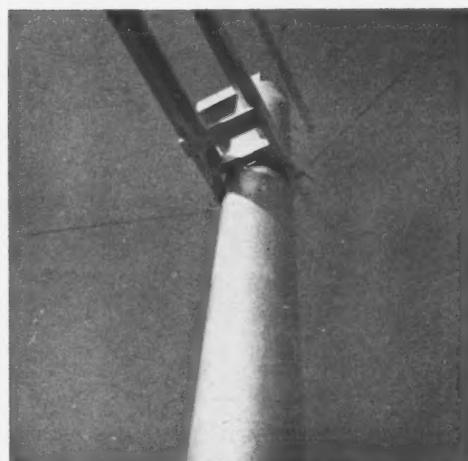
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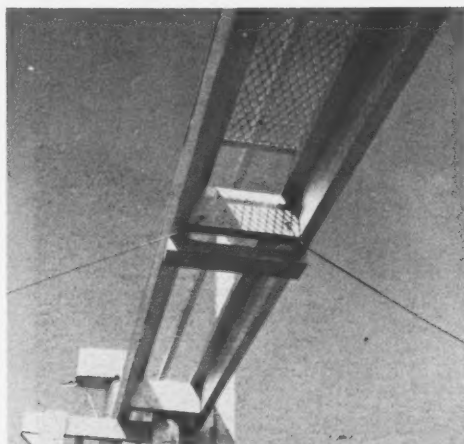
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PLATE 10

LAKE NO. 5, C. K. and WM. KITTEN

### HYDROLOGICAL DATA COLLECTED AND COMPUTED

During the study year of 1962-63 many extenuating circumstances made the collection of hydrological data for individual lakes difficult. These circumstances were unusual weather conditions and construction (modification) activities.

The water level recorder was removed from Lake No. 1 (Huckabee) in December of 1962. Water level records were maintained on this lake by a series of dated stakes, until the recorder was replaced in August of 1963. With these data, hydrological information was compiled for Lake No. 1.

Staked shore line elevations and staff gage readings were also obtained at Lakes No. 8, 9, 10 and 11. With this information curves depicting the daily volume of water and the daily surface area at each lake were drawn.

Lakes No. 2 and 6 had automatic water level recorders operating throughout the 1962-63 year. Excellent water level data is available for both of these lakes.

Lake No. 3 was served by an automatic water level recorder from September of 1962 through January of 1963. At that time the recorder, recorder tower and staff gage were removed to allow for the construction of the modification. Upon completion of the construction work, a design was made for the installation of an automatic water level recorder. A 17-foot tower was to be placed in the pit with a catwalk extending from the edge of the pit to the tower. Work had started on the catwalk and tower when a rain on May 22, 1963, filled the pit. No permanent water level recorder has yet been established in this lake. A temporary tower and water level recorder was installed in this lake in July of 1963 (see Plate 5).

A water level recorder installation was hampered at Lake No. 4 (Lubbock Christian College) in approximately the same way as it was at Lake No. 3 (Hufstедler). An automatic water level recorder was maintained on Lake No. 4 from September of 1962 through December of 1962. The recorder was then removed to allow for the modification of the lake bed area.

A recorder tower had been designed and installed when the rains of May 22, 1963, occurred (also see Plate 1). However, a short catwalk out to the tower had not been built and the recorder had not been installed in the tower. A catwalk was completed in July and a recorder installed.

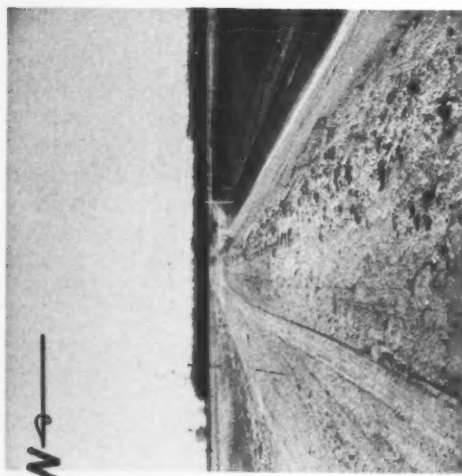
Lake No. 5 (Kitten) had a sufficient number of staff gage readings throughout the year; however, construction on the modification was in progress when the rains of May 22, 1963 occurred (see Plate 2). To allow for the completion of the modification, a lake pump was installed to pump the water out of the lake (see Plate 8, Picture 6). The lake level had been lowered appreciably when rains on June 6-7, 1963, again filled the lake. The lake pump was started about a week later and the lake was emptied. The modification was completed in mid-August and a tower, catwalk, and automatic water level recorder were installed in late August (see Plate 8, Pictures 1 through 5; Plate 9, Pictures 1 and 2; Plate 10; and Plate 11, Pictures 1 and 2).

Lake No. 7 (Cooper) was dropped from the lake program during the year 1962-63.



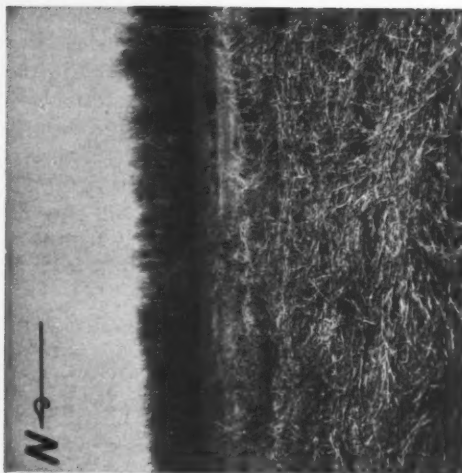
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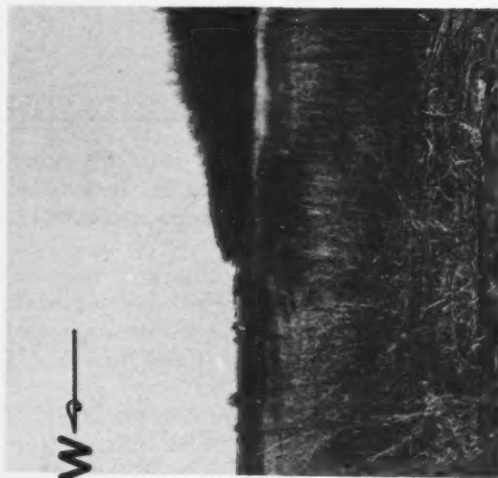


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PLATE 11



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LAKE NO. 5, C. K. and WM. KITTEN



Therefore, no water level data are available for this lake.

#### Irrigation Runoff

The hydrological equipment available to the Project does not allow for the accurate separation of rainfall runoff and irrigation runoff. Because of frequent trips to all of the lakes, a general idea of the amount of irrigation runoff can be obtained. During the year 1962-63, the amount of irrigation runoff into each of the lakes was negligible.

#### Rainfall Runoff

With all the staff gage readings, dated stake readings and automatic water level recorder records, the amount of rainfall runoff caught by each lake was determined. The runoff on an individual lake varies considerably with the amount of rainfall because of the different land preparation conditions on the watershed and length of time since the land has been irrigated.

The total amount of water caught by each lake during the 1961-62 year and the 1962-63 year is shown in Table 1.

Table 1. Total Amount of water caught by each lake during the study years 1961-62 and 1962-63.

| Lake                                   | Volume in Acre-feet<br>(1961-62) | Volume in Acre-feet<br>(1962-63) |
|----------------------------------------|----------------------------------|----------------------------------|
| Lake No. 1 (Huckabee)                  | None                             | 55.8                             |
| Lake No. 2 ( Knowles)                  | 14.7                             | 114.3                            |
| Lake No. 3 (Hufstedler)                | 5.8                              | 102.4                            |
| Lake No. 4 (Lubbock Christian College) | 34.4                             | 142.1                            |
| Lake No. 5 (Kitten)                    | 148.3                            | 152.7                            |
| Lake No. 6 (Holland)                   | 7.5                              | 140.6                            |
| Lake No. 7 (Cooper)                    | 66.2                             | No record                        |
| Lake No. 8 (Burgett)                   | No record                        | 149.7                            |
| Lake No. 9 (Cox)                       | None                             | 34.9                             |
| Lake No. 10 (Dupree)                   | 17.2                             | 51.1                             |
| Lake No. 11 (Krueger)                  | No record                        | 222.6                            |

Lake pumps were installed for short periods of time in Lakes No. 4, 5, and 8. Records of the amount of water pumped from these lakes is not available.

The cumulative volume of water caught by each lake, the cumulative rainfall at each lake, the daily volume of water in each lake, the daily surface area of each lake and a histogram of the rainfall at each lake are shown in Figures 1 through 20 (Appendix II). No curves were drawn for Lake No. 7 (Cooper).

#### Evaporation and Transpiration

Evaporation data is being collected by the Lubbock Agricultural Experiment Station in a standard Weather Bureau Type A pan. This data will be available for use

by the Project staff. When enough time becomes available, this data will be analyzed and determinations of the amount of evaporation at each lake made.

Transpiration losses from several of the lakes, with large amounts of vegetation, will probably amount to a substantial quantity. On lakes with little or no vegetation, transpiration losses will be small. It is hoped that the modification designs will eliminate vegetative growth in the water impoundment area, and thereby eliminate transpiration.

#### Percolation

Past investigations on the Southern High Plains indicate that the soils in the bottoms of the lakes are relatively impermeable. However, several of the lakes in this study appear to lose large quantities of water by percolation. Detailed analysis of the evaporation data is needed before any statement pertaining to the quantity of water lost by percolation can be made.

#### MODIFICATION OF LAKES

With the data which were collected during the first year of this study, modification designs were prepared for three lakes. During the year 1962-63, modifications were completed on Lake No. 3 (Hufstedler), Lake No. 4 (Lubbock Christian College), and Lake No. 5 (Kitten).

The modification of all three of these lakes consisted of excavating dirt from the bottom of the lake to form a pit. The material which was excavated from the pits was spread evenly onto the lake bottoms adjoining the excavations.

##### Lake No. 3 (Hufstedler)

The modification of Lake No. 3 consisted of creating a pit approximately 620 feet by 210 feet at the top, 460 feet by 140 feet at the bottom and 11.5 feet deep. This pit was constructed with side slopes of 3:1 and end slopes of 7:1 on one end and 8:1 on the other end (see Figure 1). Approximately 31,380 cubic yards of dirt were removed from this pit and spread evenly onto the adjoining lake bottom.

No berm was constructed around the top of this pit; therefore, rainfall runoff can enter the pit at any point around its perimeter. This pit, as constructed, holds 22.3 acre-feet of water with a surface area of 2.9 acres. This volume of water, prior to modification, covered 14 acres of land. Earthwork for this modification cost \$5,960.

##### Lake No. 4 (Lubbock Christian College)

The modification of the Lubbock Christian College lake consisted of excavating 45,200 cubic yards of dirt from the bottom of the lake at a cost of \$8,590. The excavation created a pit approximately 850 feet by 350 feet at the top, 280 feet by 100 feet at the bottom and 13.5 feet deep. A large portion of the dirt excavated from the pit, 34,300 cubic yards, was spread evenly onto the lake bottom adjoining the pit. The other 10,900 cubic yards of dirt removed from the pit were carried approximately 1 mile from the lake and deposited in an area where some fill work was being done by Lubbock Christian College. In order to comply with a request of the Lubbock Planning

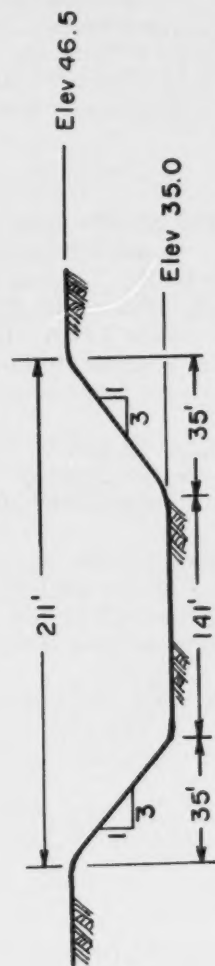
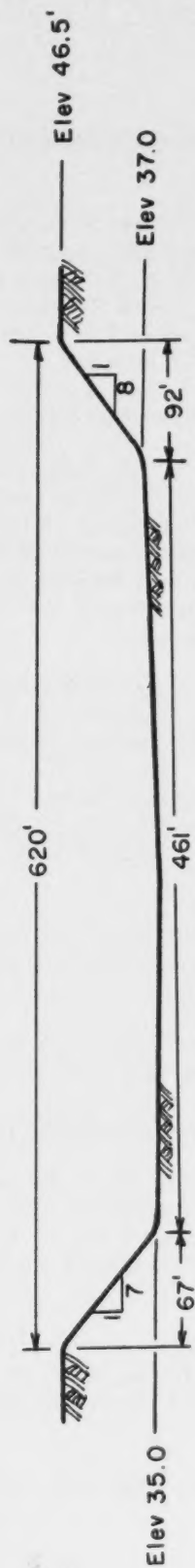
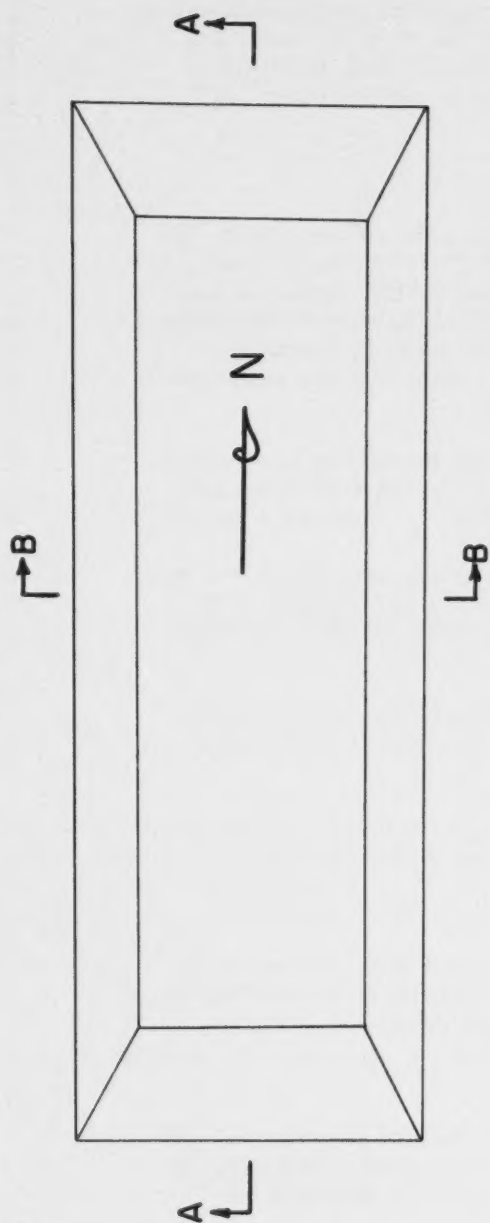


FIGURE I - SKETCH PLANS, HUFSTEDLER LAKE PIT

and Zoning Commission, the Lubbock Christian College pit was constructed with side slopes of 10:1.

As in the case of Lake No. 3 (Hufstedler), no berm was constructed around the top of the Lubbock Christian College pit. Rainfall runoff can enter the pit at any point along its perimeter; however, most of the water will enter the pit at its southwest corner (see Plate 12, Pictures 1, 2 and 3). This pit, as constructed, holds 33.5 acre-feet of water with a surface area of 6.4 acres. Prior to modification, 33.5 acre-feet of water would cover 17.0 acres.

#### Lake No. 5 (Kitten)

The modification at Lake No. 5, although it is a pit, is quite different from the other two modifications. This lake is almost evenly divided by Highway 41 (see Appendix I). To modify this lake correctly would have required the digging of a pit on both sides of the Highway. Insufficient funds were available to modify both sides of the Kitten Lake. Therefore, it was decided to create two lakes by blocking a culvert beneath Highway 41. An agreement with the Texas State Highway Department, to obstruct this culvert, was obtained.

A pit 78 feet by 917 feet at the top, 10 feet by 698 feet at the bottom and 17 feet deep was constructed on the western side of the lake. The eastern side of the lake was left unmodified and will serve as a check lake (see Plate 11, Pictures 3 and 4).

This pit was constructed with side slopes of 2:1 and end slopes of 5:1 on one end and 7:1 on the other end (see Figure 2). Approximately 21,500 cubic yards of dirt was excavated at a cost of \$3,870. This dirt was spread evenly onto the adjoining lake bottom (see Plate 3, Picture 5).

A berm was constructed around the north, south and west sides of this pit (see Plate 11, Picture 2). Rainfall runoff can enter the pit on only the east side where an entrance channel has been excavated.

This pit will hold 15.0 acre-feet of water with a surface area of 1.7 acres when full. This volume of water covered 14.7 acres of land prior to modification.

#### Condition of Pit Areas

Plate 4 illustrates erosional and storm damage associated with the Hufstedler (Lake No. 3) pit. Pictures 1 and 2 indicate storm and ice damage to the staff gage. Ice ridges are illustrated by Pictures 3 and 4. Severe wave erosion is noted in Picture 5. An alluvial fan, in the southwest corner of the pit, is illustrated by Picture 6.

Erosional damage to the Hufstedler lake pit is notable but not alarming. This damage does, however, indicate the necessity of remedial measures (dike and controlled access to the pit area, etc.) which will have to be taken to increase the longevity of this pit.

Wave erosion was greater than expected, and the observed ice flowage will



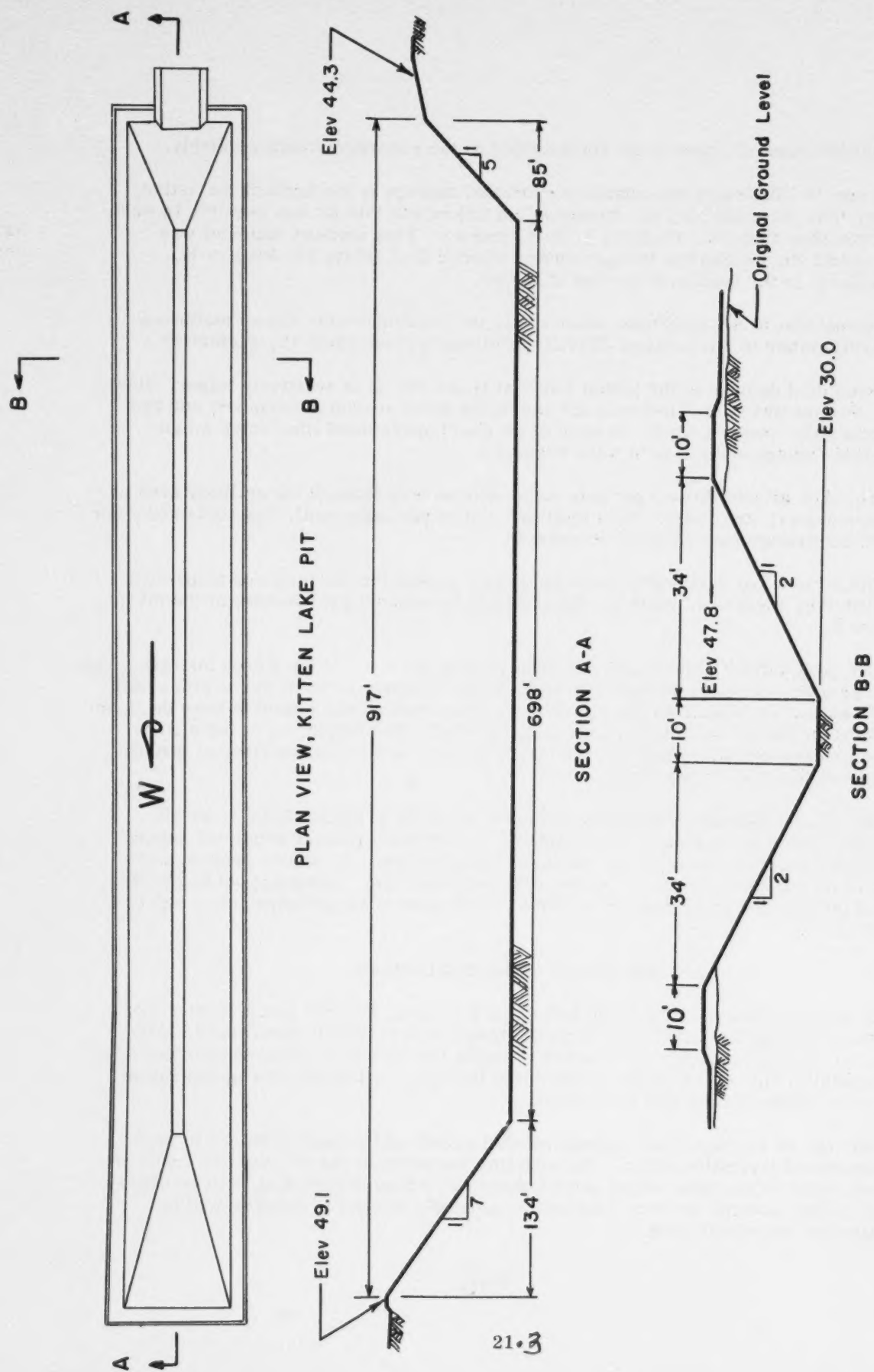


FIGURE 2- SKETCH PLANS, KITTEN LAKE PIT

necessitate some changes in the construction of the recording tower assembly.

Plate 12 illustrates the extensive erosional damage to the Lubbock Christian College lake pit (Lake No. 4). Uncontrolled inflow into this pit has resulted in washout areas (see Plate 12, Pictures 2, 3, 4, and 6). This washout material was carried into the pit and has built extensive alluvial fans (Plate 12, Picture 1), particularly in the southwest portion of the pit.

In contrast to the conditions observed in the Hufstedler pit, wave erosion was relatively minor in the Lubbock Christian College pit (see Plate 12, Picture 5).

Erosional damage to the Kitten Lake pit (Lake No. 5) is relatively minor. However, this pit was completed near the end of the rainy season (September) and has not been fully "water"tested. In spite of its short operational life, some minor erosional damage and siltation were observed.

The dike around this pit permits water access only through the spillway area at the pit's eastern extremity. This spillway, cut in the native soil, has sustained some erosional damage (see Plate 9, Picture 5).

Numerous, but very small wash areas can be noted in the west end slope area, illustrated by Picture 4, Plate 9. Siltation can be observed in the base of the pit in Picture 6.

An unexplained joint system was observed in the sides of the Kitten lake pit. This crack or joint, shown in Pictures 3 and 4, Plate 3, appeared to be filled with a soil matrix indicative of near surface material. This system was traced to near the upper periphery of the pit and into the pit's opposite wall. The origin, (it is not a root system) extent and effect this system may have had, or has, on infiltration through the base of this lake is not known.

Mr. A. C. Bowden, consulting engineer, is in the process of designing pit entrances, based on empirical relationships, which will minimize erosional damage. The double recorder installation, discussed in previous text, should provide some insight into the near maximum inflow rates and velocities, thereby providing much needed information around which workable inflow systems (spillways, etc.) can be designed.

#### Advantages of Pit Modifications

By constructing the pits in the bottom of the lakes, rainfall runoff from small storms and irrigation runoff can be concentrated in a relatively small area. Also, the water surface area per acre-foot of water in the pit can be reduced considerably. Consequently, the total amount of water lost through evaporation and transpiration in a given length of time will be reduced.

During an average year, enough rainfall runoff will collect in the pit to serve as a source of irrigation water. By confining the water to the pit, former areas of shallow water in the lake, which were conducive to mosquito breeding, will be eliminated. Also, several acres of lake bottom normally subject to flooding will be salvaged for beneficial uses.



1



2



3



4



5



6

PLATE 12 LAKE NO. 4, LUBBOCK CHRISTIAN COLLEGE

At the time of this writing the owners of the Kitten lake have installed a standpipe assembly and underground pipeline (see Plate 9, Pictures 3 and 4) in preparation for pumpage from this lake.

A disadvantage of the pit modifications is that an acre-foot of dirt has to be moved to create an acre-foot of storage. A diversion terrace and dam could create more storage area with less dirt movement. Such a modification is in the design stage for the coming year.

Although the pits were designed to take care of most rainfalls, they cannot take care of an extremely large rain (see Plate 1; Plate 2; and the back cover). Also, the slow accumulation of rainfall runoff from several small storms can completely fill the pit. For this reason, it is felt that a lake pump should be installed in the lake and the water pumped out as soon as possible after each storm.

The adaptation of modified lakes to provide a habitat for fish and wildlife has not been fully explored. However, it is evident that pumpage from such lakes will have to be restricted to maintain a selected minimal dead storage.



# Part IV

## PROJECTED INVESTIGATIONS AND WORK PLANS

Progress Staff

DIRECTED AND ADMINISTERED BY

Dr. David M. Cowgill

Director, Lubbock City-County Health Unit

and

Mr. William L. Broadhurst

Chief Hydrologist, High Plains Underground Water Conservation District

COORDINATED BY

Mr. Walter Breedlove

Chief Public Health Engineer, Lubbock City-County Health Unit

## WORK PLANS FOR THE BIOLOGICAL PHASES OF THE STUDY

The same base line that has been used for the last two seasons on biological studies will be continued on modified and unmodified lakes. Two modified lakes at the present time have water in them. This will allow studies to be continued through the winter months on water chemistry, water temperature studies and wildlife observations on these lakes.

Vegetative patterns on modified and unmodified lakes will be compared. Variations of vegetative growth on study lakes have been observed in the last two years of the study.

A continuation of the Gambusia studies will include plans for three more modifications in mosquito producing lakes. Each plan will be designed to have variations in spoil disposal, orientation and size of pit.

The temperature recorder recently completed will be installed in one of the study lakes to record water temperature and weather information. Seasonal light trap records will be kept on two lakes that are fixed with drops for plugging in the light traps.

Laboratory studies will include temperature and photoperiod requirements of mosquitoes. A chromatograph machine has been requested to facilitate studies of insecticides in playa lake water.

Also included in the work plans for the coming season is an evaluation of correlation between depth, vegetative cover, and regression analysis that will be made from the data already derived from the study, and these data will then be tested in the field.

## WORK PLANS FOR THE HYDROLOGICAL PHASES OF THE STUDY

During the study year September 1, 1963-August 31, 1964, plans call for some additional dirt work to be done on both Hufstedler lake and Kitten lake to help check erosion.

In addition to this work, plans call for the modification of two (possibly three) additional lakes. It is hoped that at least one of these modifications will include the use of diversion terraces and a dirt-fill dam. As was pointed out in Part III, Mr. A. C. Bowden, consulting engineer, is designing several entrance structures for use with the pits.

In August of 1963, six additional water-level recorders were purchased. With this equipment, more and better water level data will be available for study during the study year 1963-64.

One of the recorders purchased is a Leupold-Stevens type A35 recorder. This recorder will record both water levels and precipitation. A tilting bucket type precipitation recorder was purchased with the A35 recorder. With both rainfall and water level data, some rainfall-runoff relationships will be developed for the watershed of one of the lakes.

## APPENDICES

I. Lake Bed Contour Maps and Elevation-  
Area and Elevation-Volume Curves

II. Hydrological Data

III. Mosquito Larvae Production Graphs

IV. Water Chemistry Data

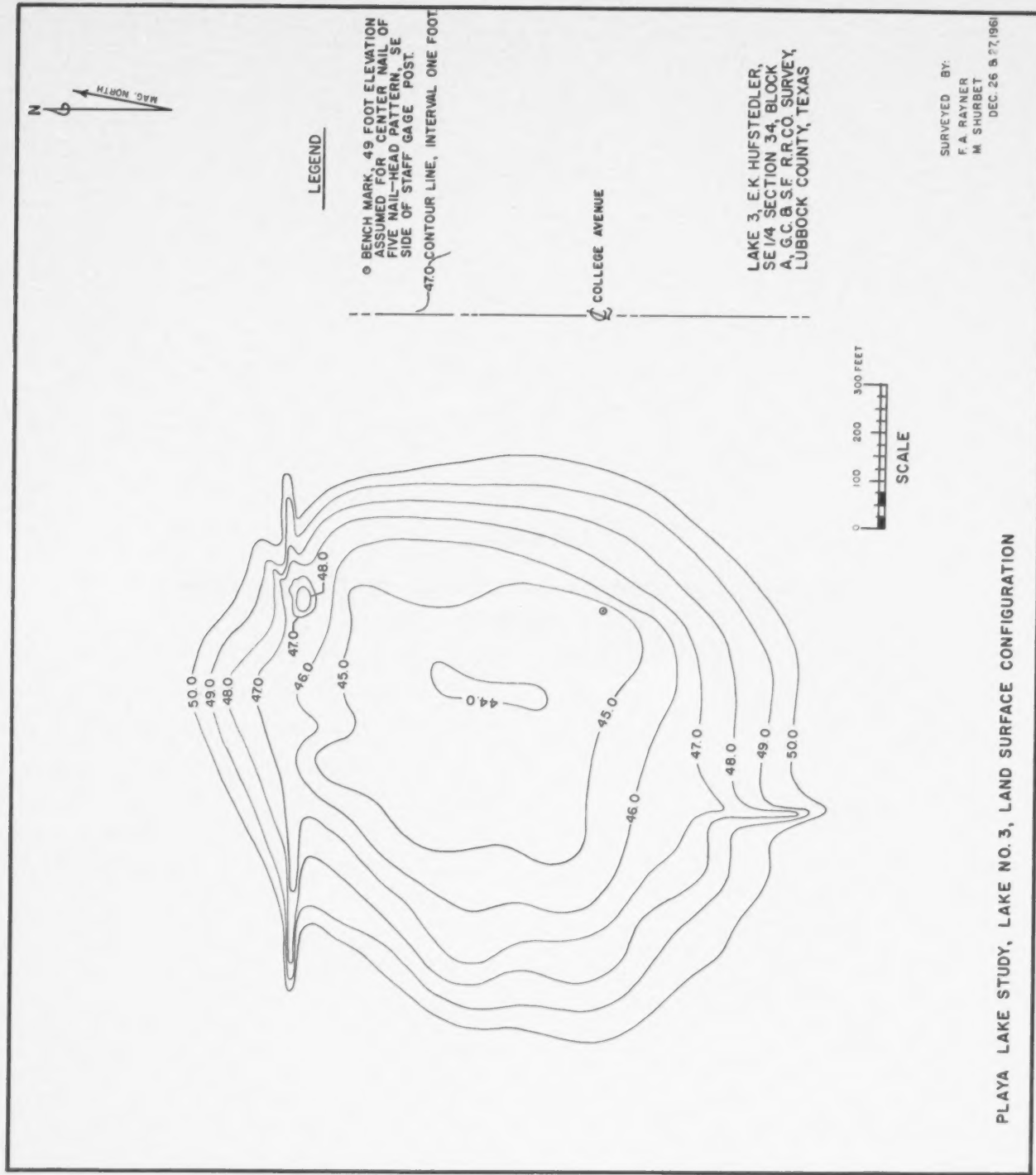
V. Wildlife and Vegetation Data

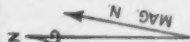
2.4-b

APPENDIX I.

Lake Bed Contour Maps and Elevation-Area and Elevation-Volume  
Curves





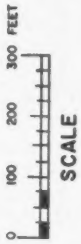
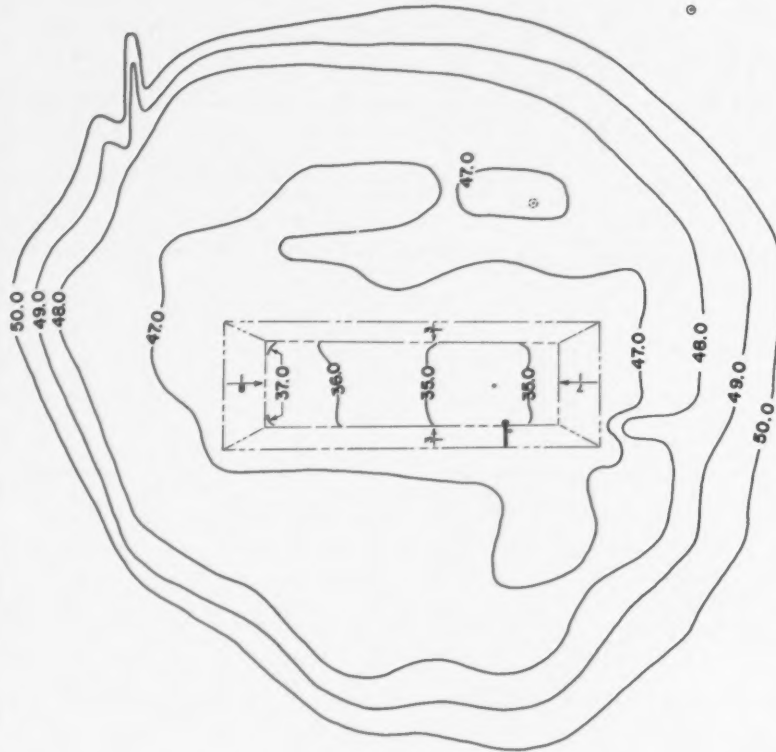


# **LEGEND**

- BENCH MARK, ELEVATION 52.11 FEET FOR A POINT 5 INCHES S OF THE N EDGE AND 4 FEET W OF THE E EDGE (13 FEET E OF BARN) OF THE CONCRETE APRON ON THE E SIDE OF THE CORRUGATED STEEL BARN.
- FORMER BENCH MARK (STAFF GAGE) LOCATION
- 10' CONTOUR LINE, ONE FOOT INTERVAL.
- - - APPROXIMATE PIT BOUNDARIES, OUTER BOUNDARY ELEVATION 48.54 FEET.
- + DIRECTION OF PIT SIDE SLOPE HERE SHOWN AS ONE FOOT VERTICAL DROP PER THREE FEET OF HORIZONTAL TRAVEL.
- RECORDER TOWER INSTALLATION - NOT TO SCALE.
- STAFF GAGES

COLLEGE AVENUE

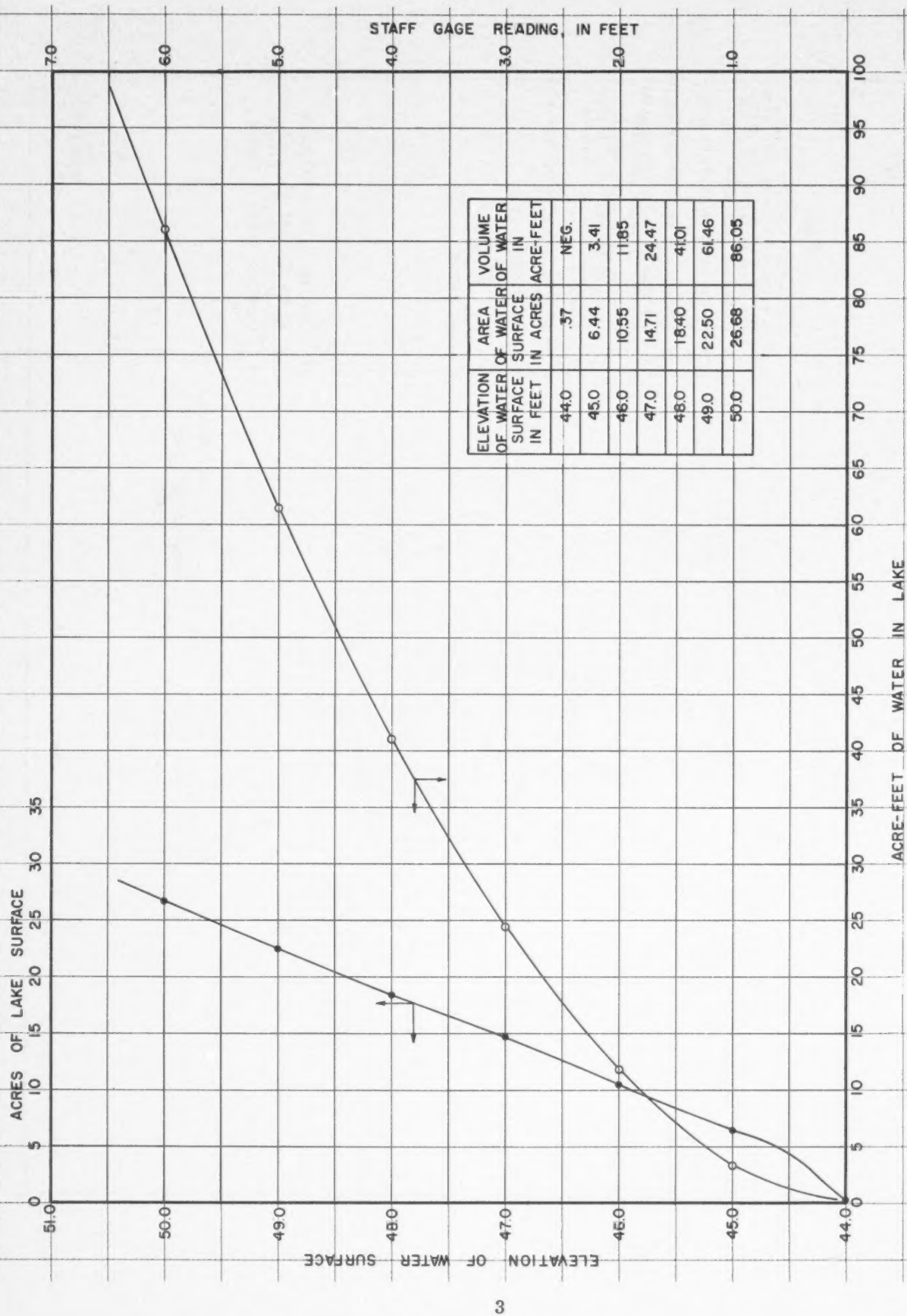
LAKE NO. 3, E. K. HUFSTEDLER  
SE 1/4 SECTION 34, BLOCK A  
G.C. & S.F. RR CO. SURVEY  
LUBBOCK COUNTY, TEXAS



SCALE

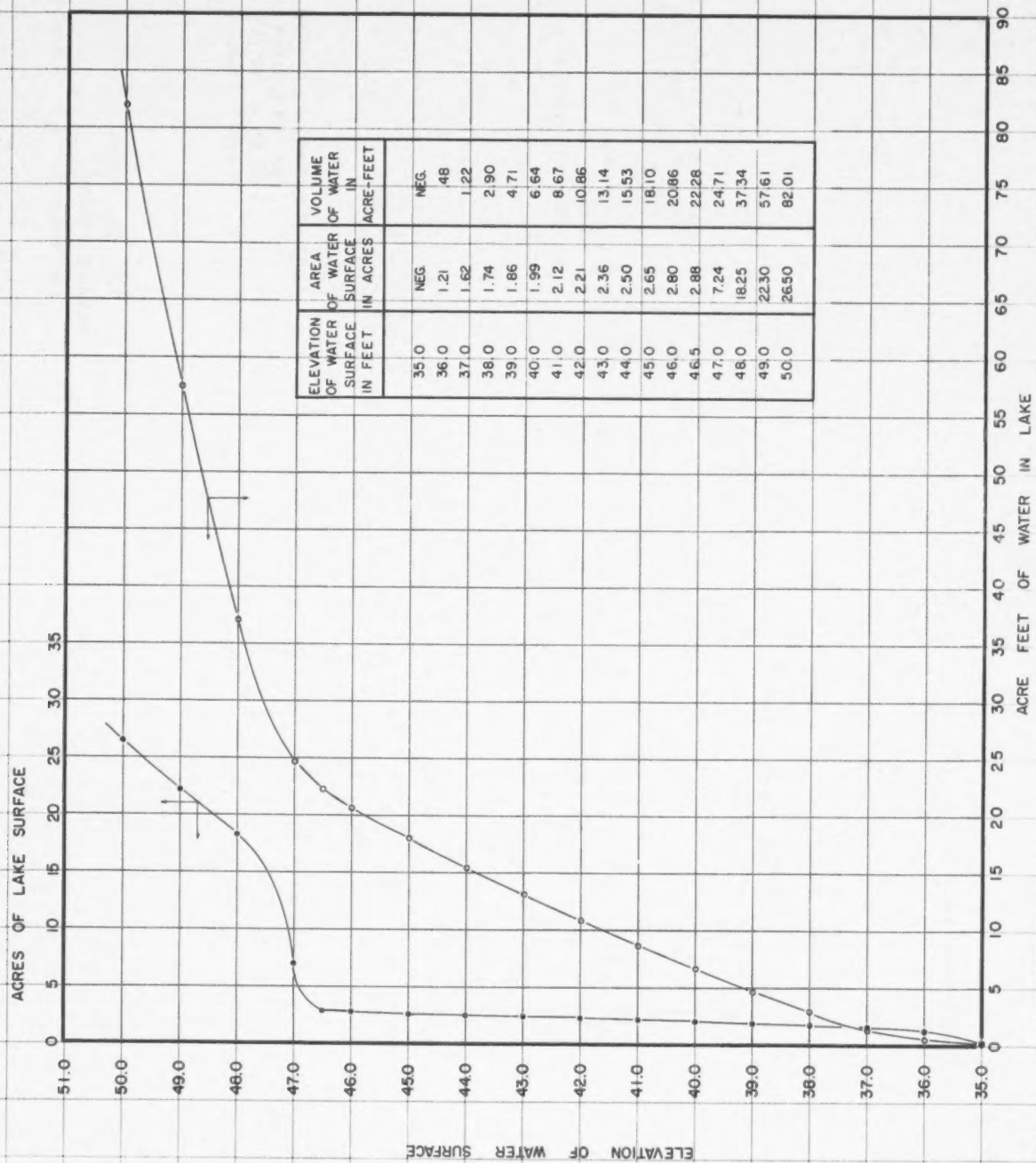
SURVEYED  
FR & M.S., DEC 1961  
S. C. HOFMEIER  
FR & M.S., DEC 1963

PLAYA LAKE STUDY, LAKE NO. 3, LAND SURFACE CONFIGURATION



AREA-VOLUME-ELEVATION CURVES FOR LAKE NO. 3, LOCATED IN SE 1/4 OF SECTION 38, BLOCK A, G.C. & S.F. R.R. CO. SURVEY, LUBBOCK COUNTY, TEXAS.

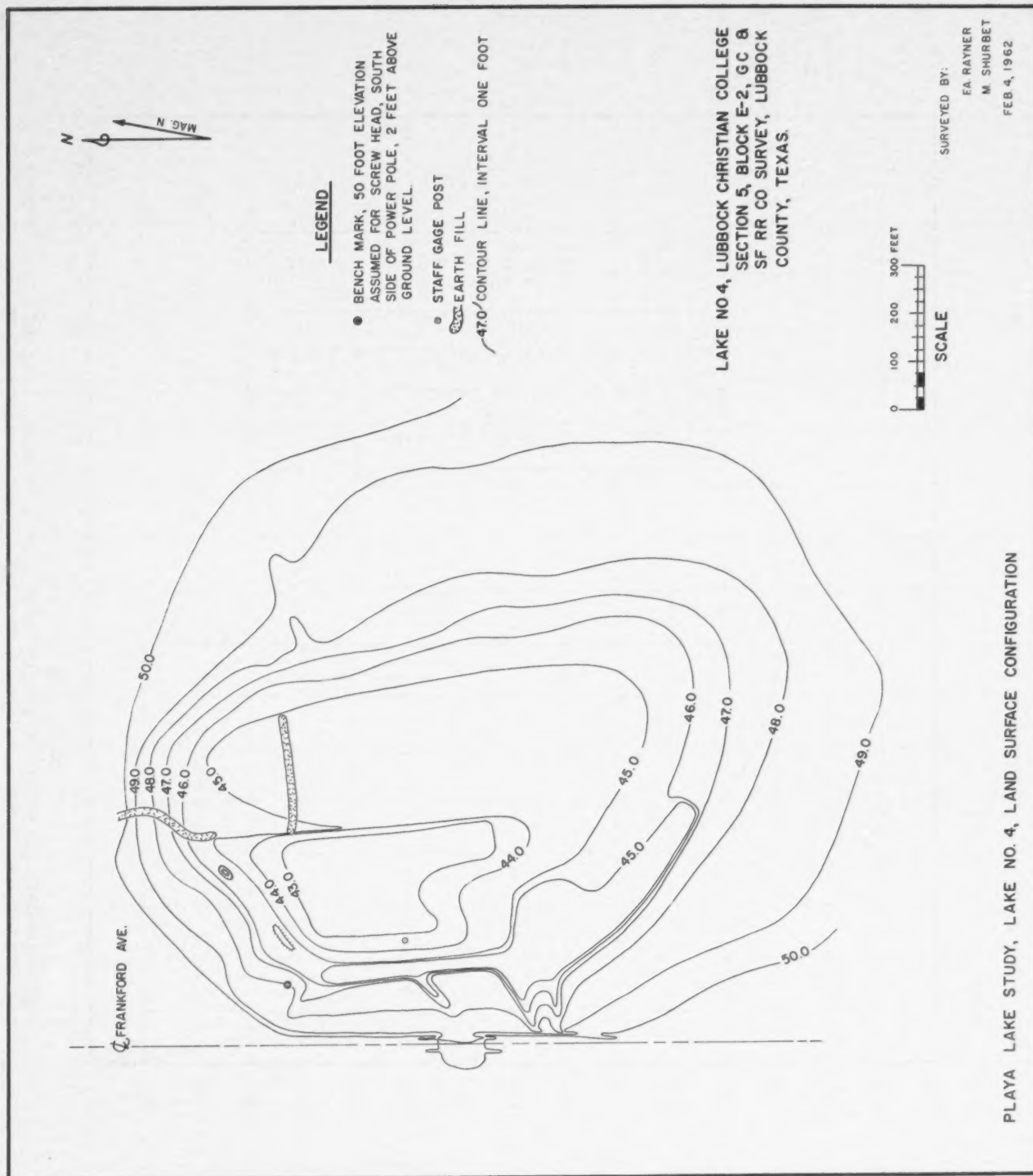
DRAWN BY: F.A. RAYNER  
JAN. 1, 1962

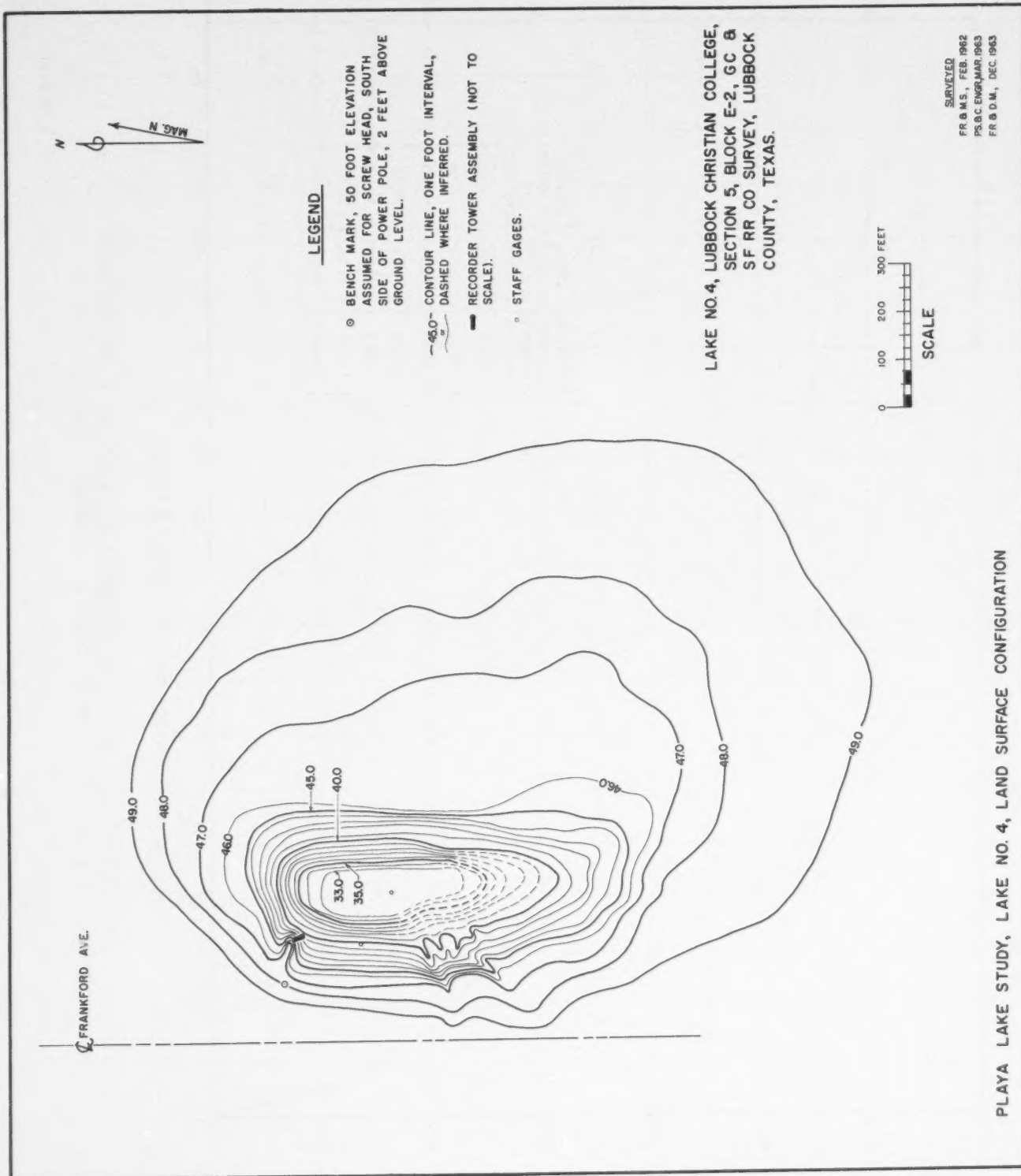


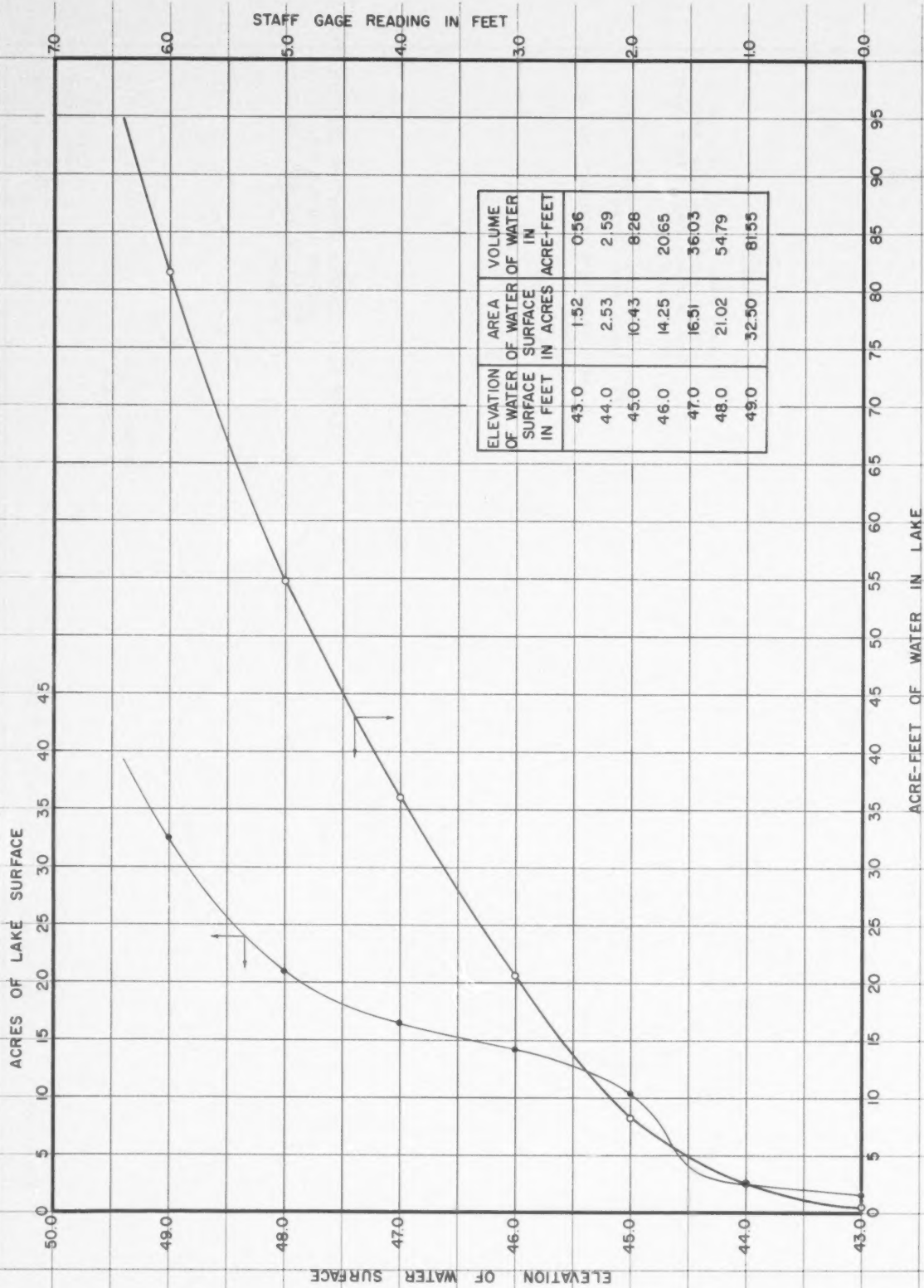
ELEVATION-AREA & ELEVATION-VOLUME CURVES, E.K. HUFSTEDLER, LAKE NO. 3,  
SE.1/4 SECTION 34, BLOCK A, G.C. & S.F.R. CO. SURVEY, LUBBOCK COUNTY, TEXAS

BY FR. D. B. M. M.  
1-4-64



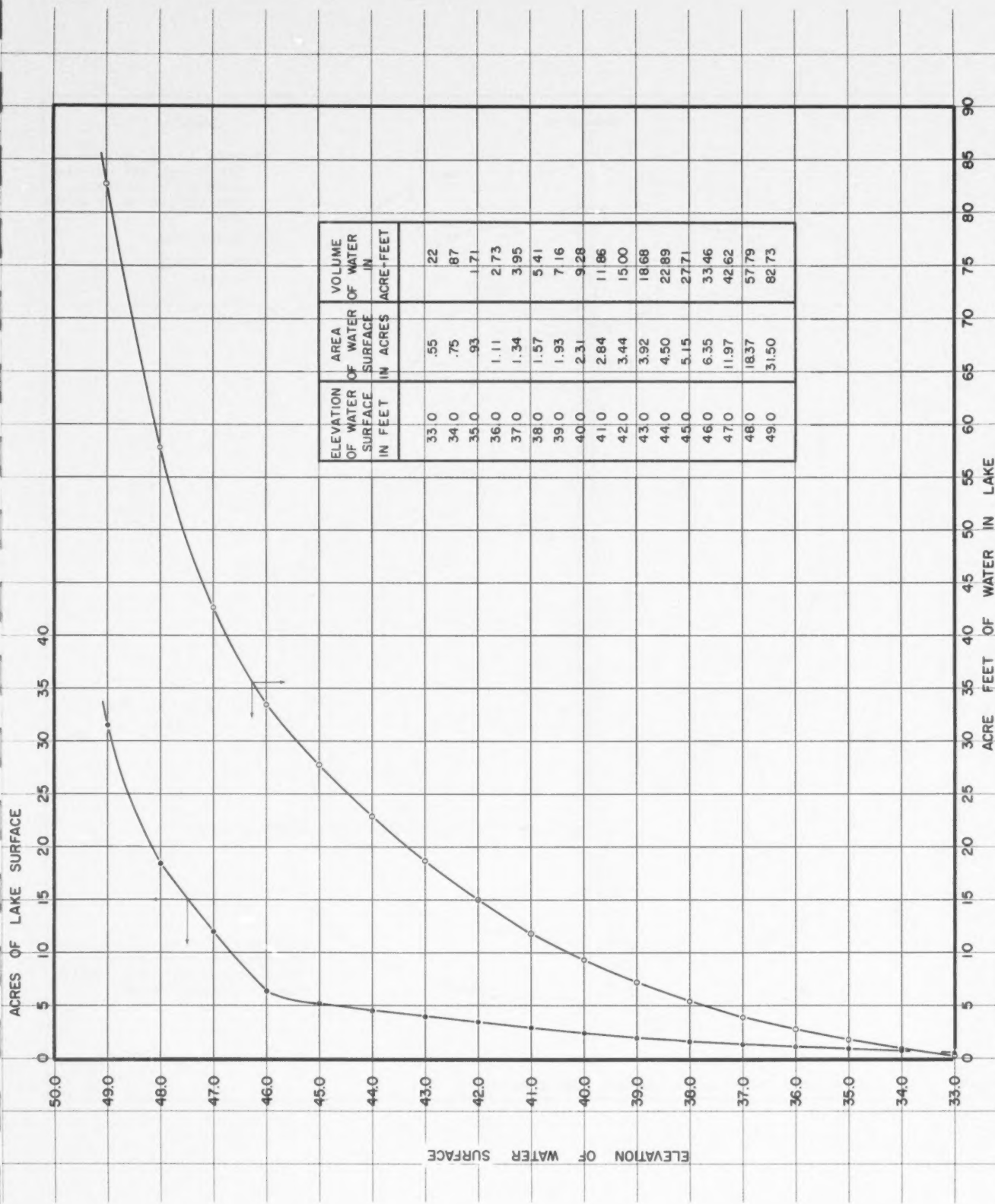






ELEVATION-VOLUME AND AREA CURVES, FOR LAKE NO. 4, IN SECTION 5,  
BLOCK E-2, GC & SF RR CO. SURVEY, LUBBOCK COUNTY, TEXAS.

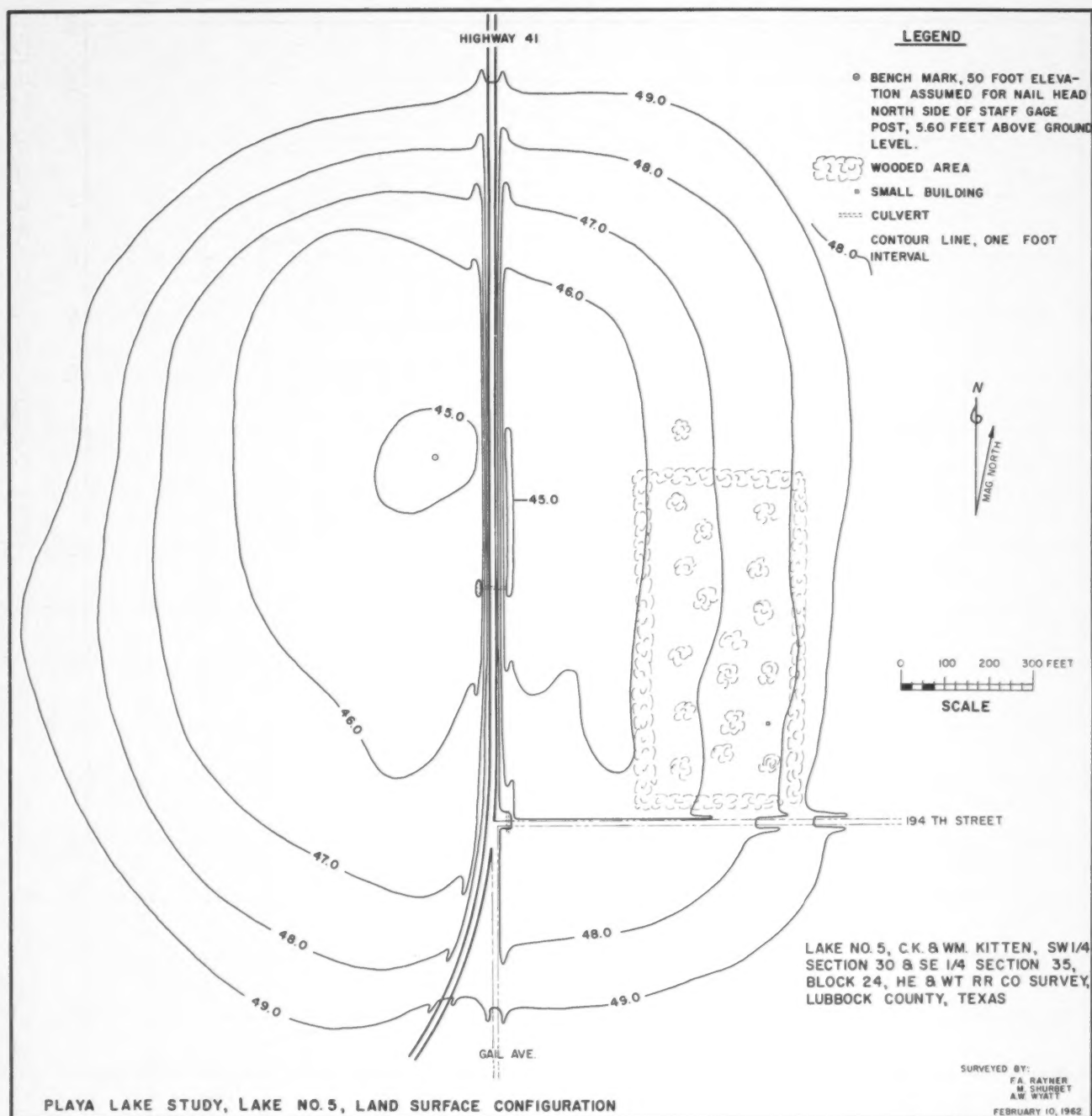
DRAWN BY:  
F.A. RAYNER  
FEB. 11, 1962

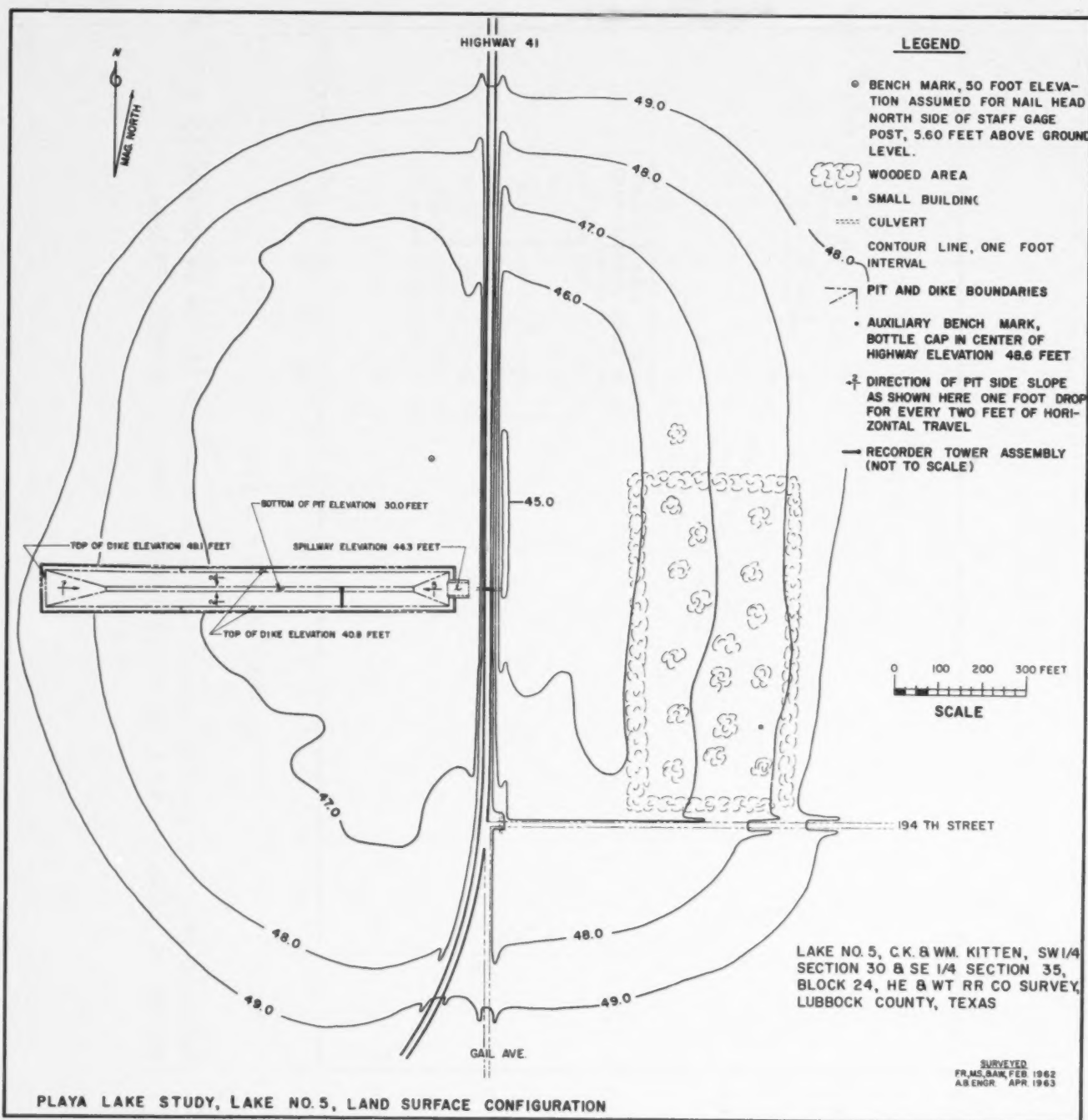


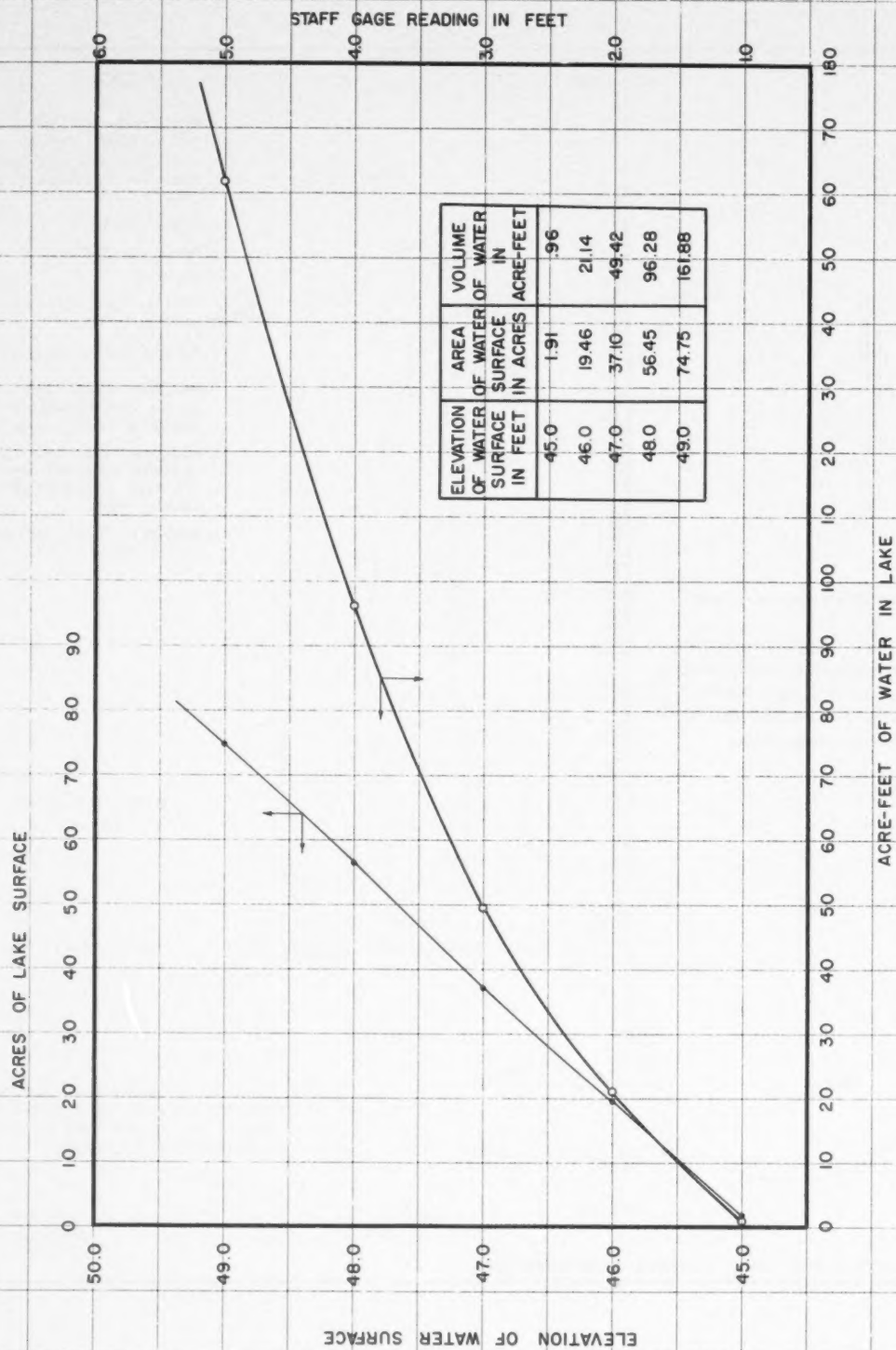
| ELEVATION<br>OF WATER<br>SURFACE<br>IN FEET | AREA<br>OF WATER<br>SURFACE<br>IN ACRES | VOLUME<br>OF WATER<br>IN<br>ACRE-Feet |
|---------------------------------------------|-----------------------------------------|---------------------------------------|
| 33.0                                        | .55                                     | 22                                    |
| 34.0                                        | .75                                     | 87                                    |
| 35.0                                        | .93                                     | 171                                   |
| 36.0                                        | 1.11                                    | 273                                   |
| 37.0                                        | 1.34                                    | 395                                   |
| 38.0                                        | 1.57                                    | 541                                   |
| 39.0                                        | 1.93                                    | 716                                   |
| 40.0                                        | 2.31                                    | 928                                   |
| 41.0                                        | 2.84                                    | 1186                                  |
| 42.0                                        | 3.44                                    | 1500                                  |
| 43.0                                        | 3.92                                    | 1868                                  |
| 44.0                                        | 4.50                                    | 2289                                  |
| 45.0                                        | 5.15                                    | 2771                                  |
| 46.0                                        | 6.35                                    | 3346                                  |
| 47.0                                        | 11.97                                   | 4262                                  |
| 48.0                                        | 18.37                                   | 5779                                  |
| 49.0                                        | 31.50                                   | 8273                                  |

ELEVATION-AREA & ELEVATION-VOLUME CURVES, LUBBOCK CHRISTIAN COLLEGE, LAKE NO. 4,  
SECTION 5, BLOCK E-2, G.C. & S.F.R. CO. SURVEY, LUBBOCK COUNTY, TEXAS  
BY: FR. J.M. & M.M.  
1-5-64



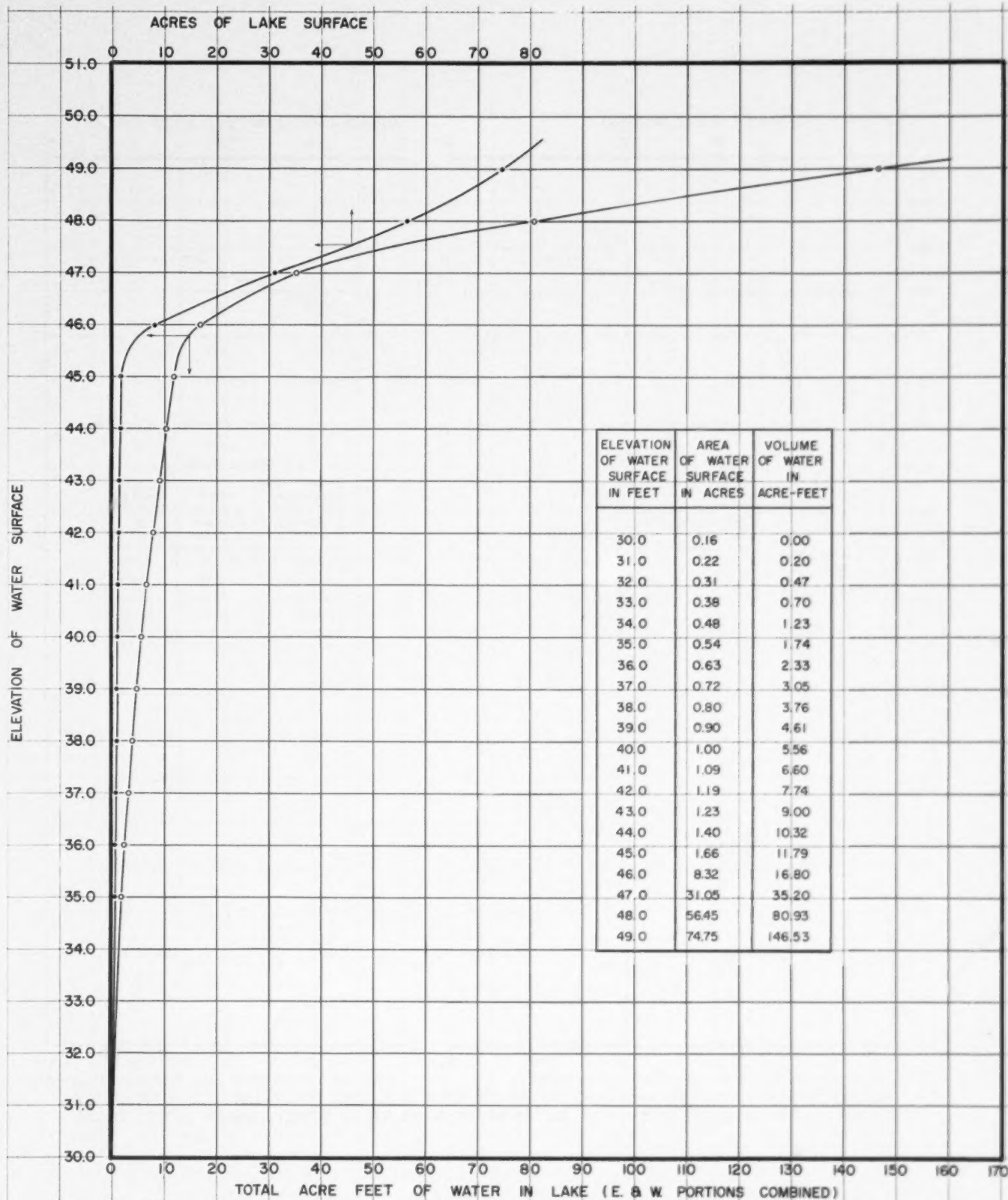






ELEVATION-AREA & ELEVATION-VOLUME CURVES, LAKE NO. 5, IN THE SW 1/4 SECTION 30 & SE 1/4 SECTION 35, BLOCK 24, HE & WT RR CO SURVEY, LUBBOCK COUNTY, TEXAS.

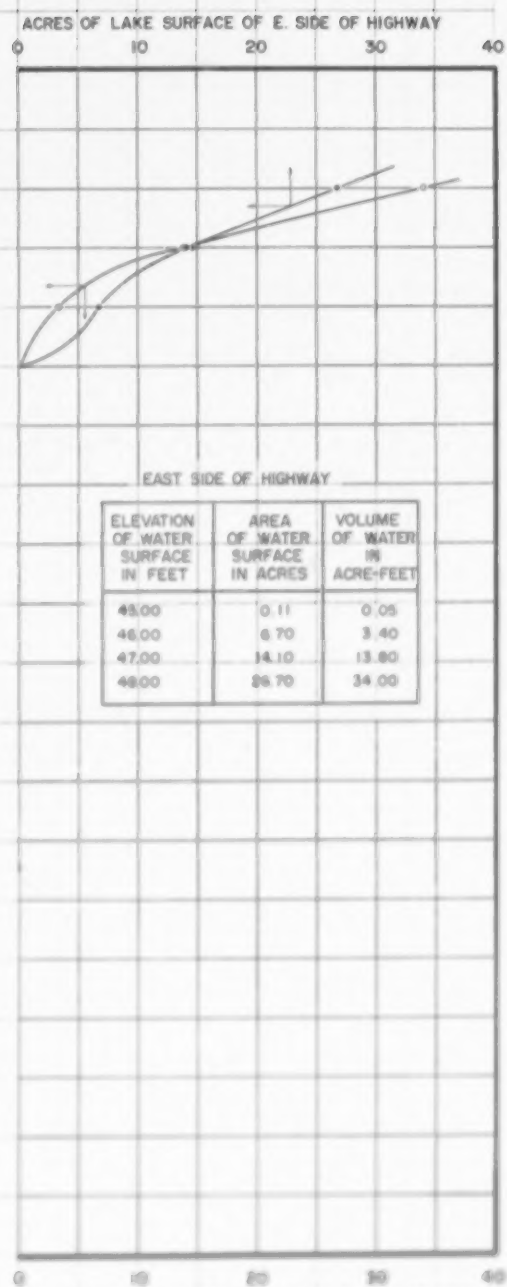
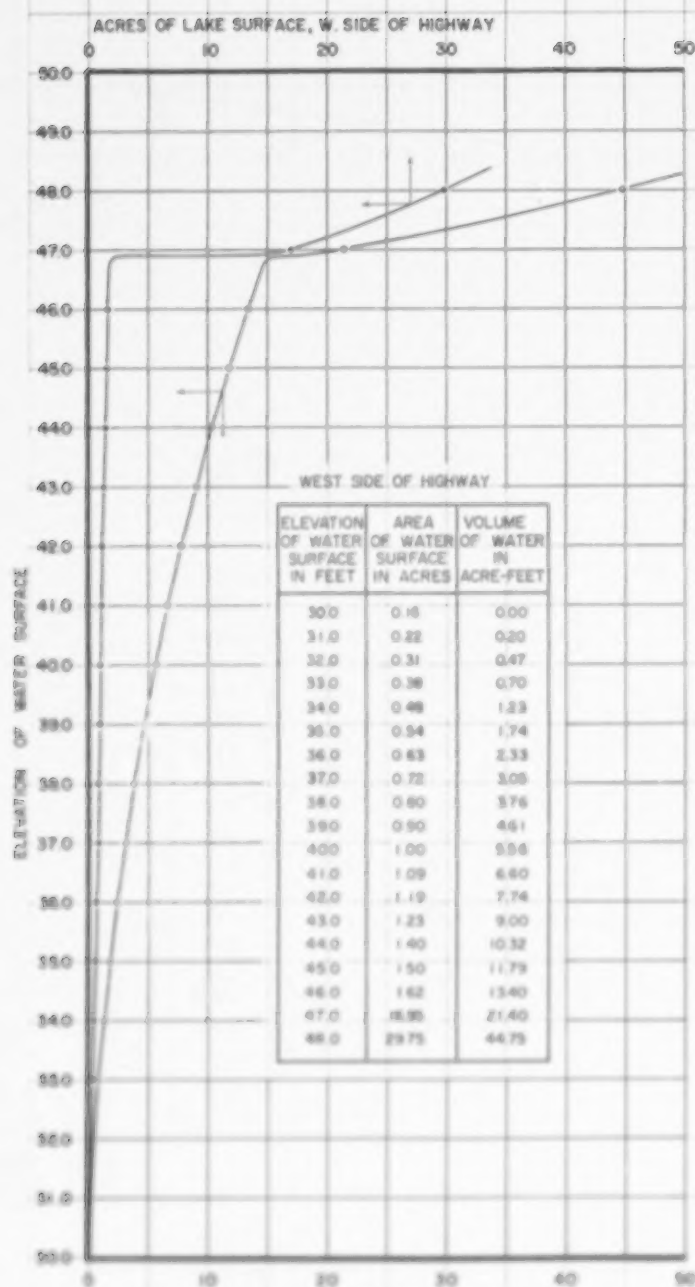
DRAWN BY:  
PA. RAYNER  
APRIL 22, 1960



ELEVATION-AREA & ELEVATION-VOLUME CURVES, C.K. & WM. KITTEN, LAKE NO. 5, S.W. 1/4 SECTION 30 & S.E. 1/4 SECTION 35, BLOCK 24, H.E. & W.T. R.R. CO. SURVEY, LUBBOCK COUNTY, TEXAS

BY E. R. & M. M.





ELEVATION-AREA & ELEVATION-VOLUME CURVES FOR THE E. & W. SIDES OF LAKE NOS. C.R. & WM. RITTEN  
S.E. 1/4 SECTION 35, BLOCK 24, & S.W. 1/4 SECTION 30, H.E. & W.T. R.R. CO. SURVEY, LUBBOCK COUNTY, TEXAS.

BY 11-2-45  
11-2-45



# LEGEND

○ BENCH MARK - STAFF GAGE, 50 FOOT ELEVATION ASSUMED FOR TOP OF CONCRETE FOUNDATION SOUTH SIDE OF STAFF GAGE POST

---530--- CONTOUR LINE, ONE FOOT INTERVAL, DASHED WHERE INFERRED.

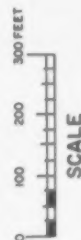
---505--- SUPPLEMENTARY CONTOUR LINE; INTERVAL .5 FOOT

||||| CULVERT, ELEVATION OF TOP OF CENTER OF CONCRETE ABUTMENT, EAST SIDE, 61.0 FEET.

▢ PIT, APPROXIMATELY 6 FEET DEEP.



LAKE NO. 11, J. KRUEGER, SE 1/4  
SECTION 11, BLOCK E  
GC & S.F.R.R. CO. SURVEY  
LUBBOCK COUNTY, TEXAS



SURVEYED: DEC. 1963  
BY: D.R., F.R. & D.M.

PLAYA LAKE STUDY, LAKE NO. 11, LAND SURFACE CONFIGURATION

ACRES OF LAKE SURFACE

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APPENDIX II.  
Hydrological Data



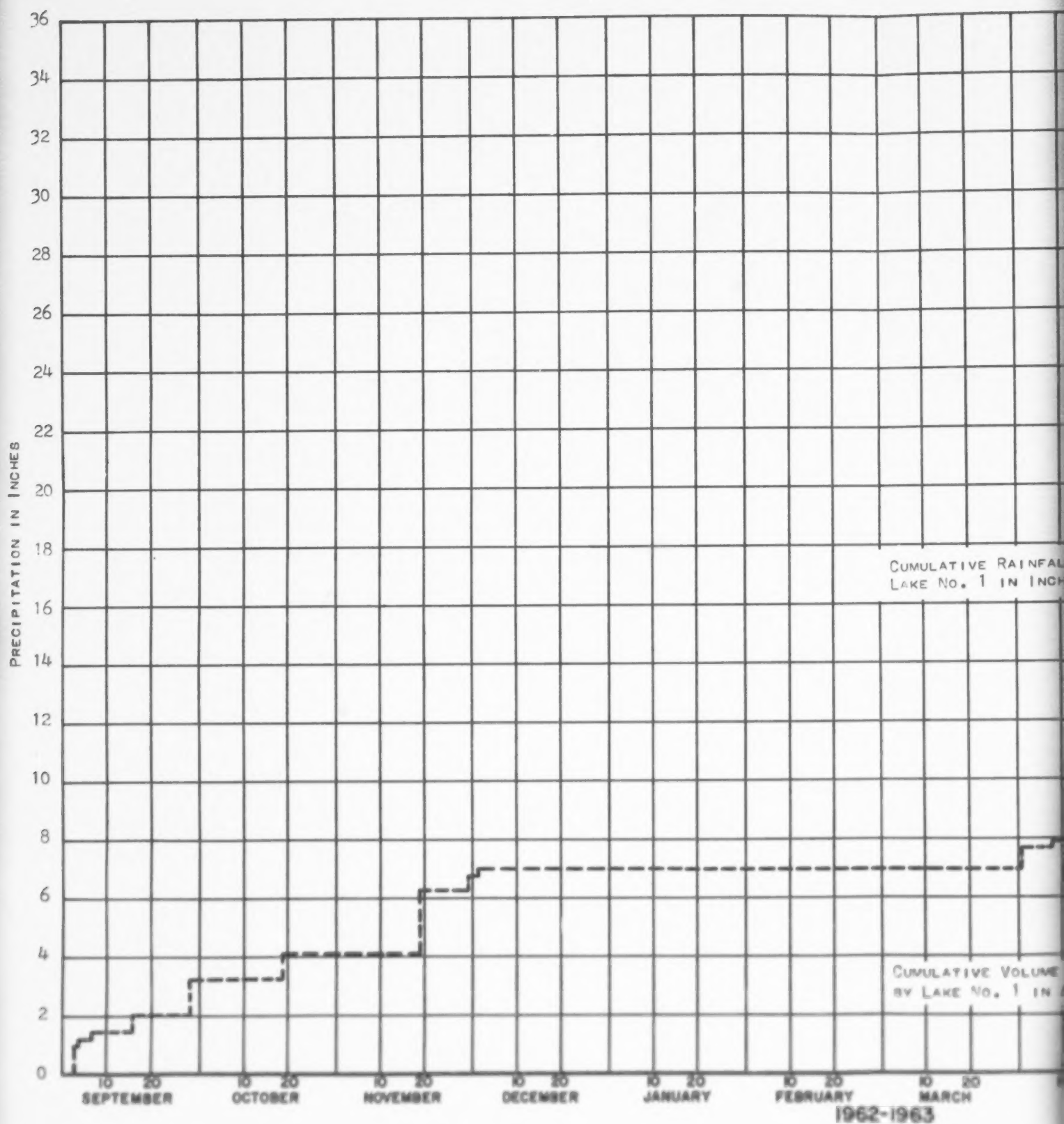
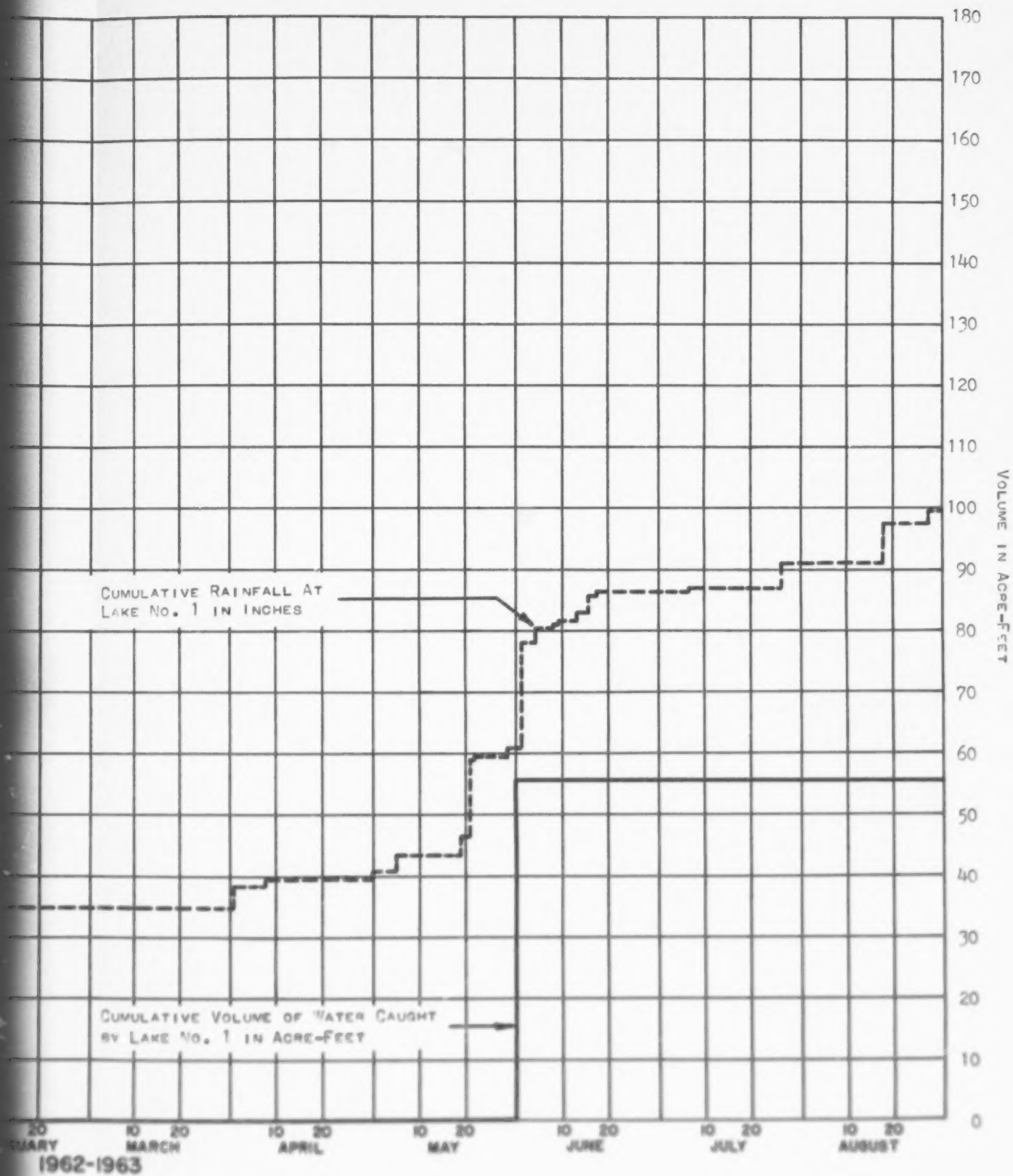


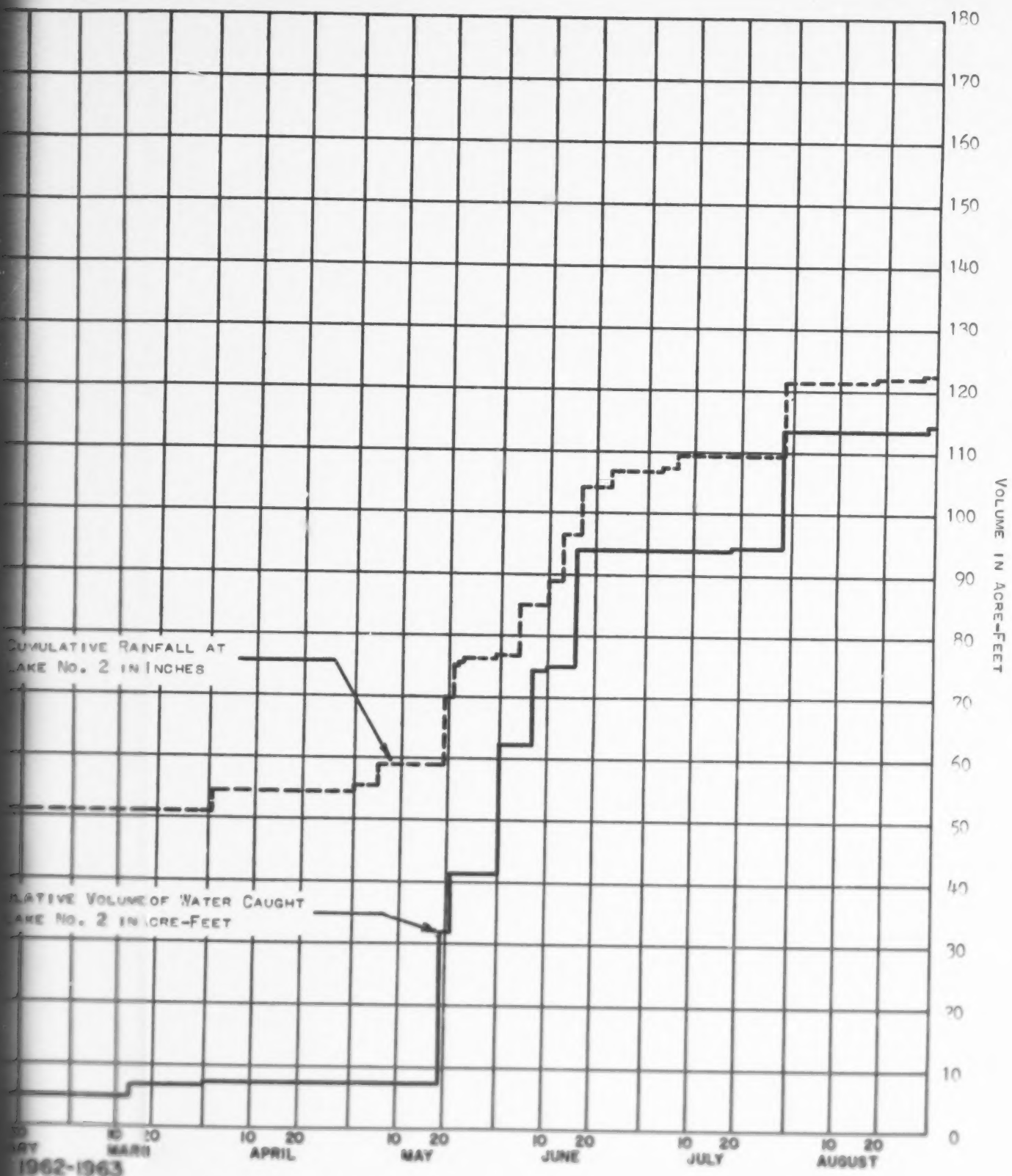
FIGURE 1. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER CAN



CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE NO. 1 (HUCKABEE).



FIGURE 7. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER BY LAKE NO. 2





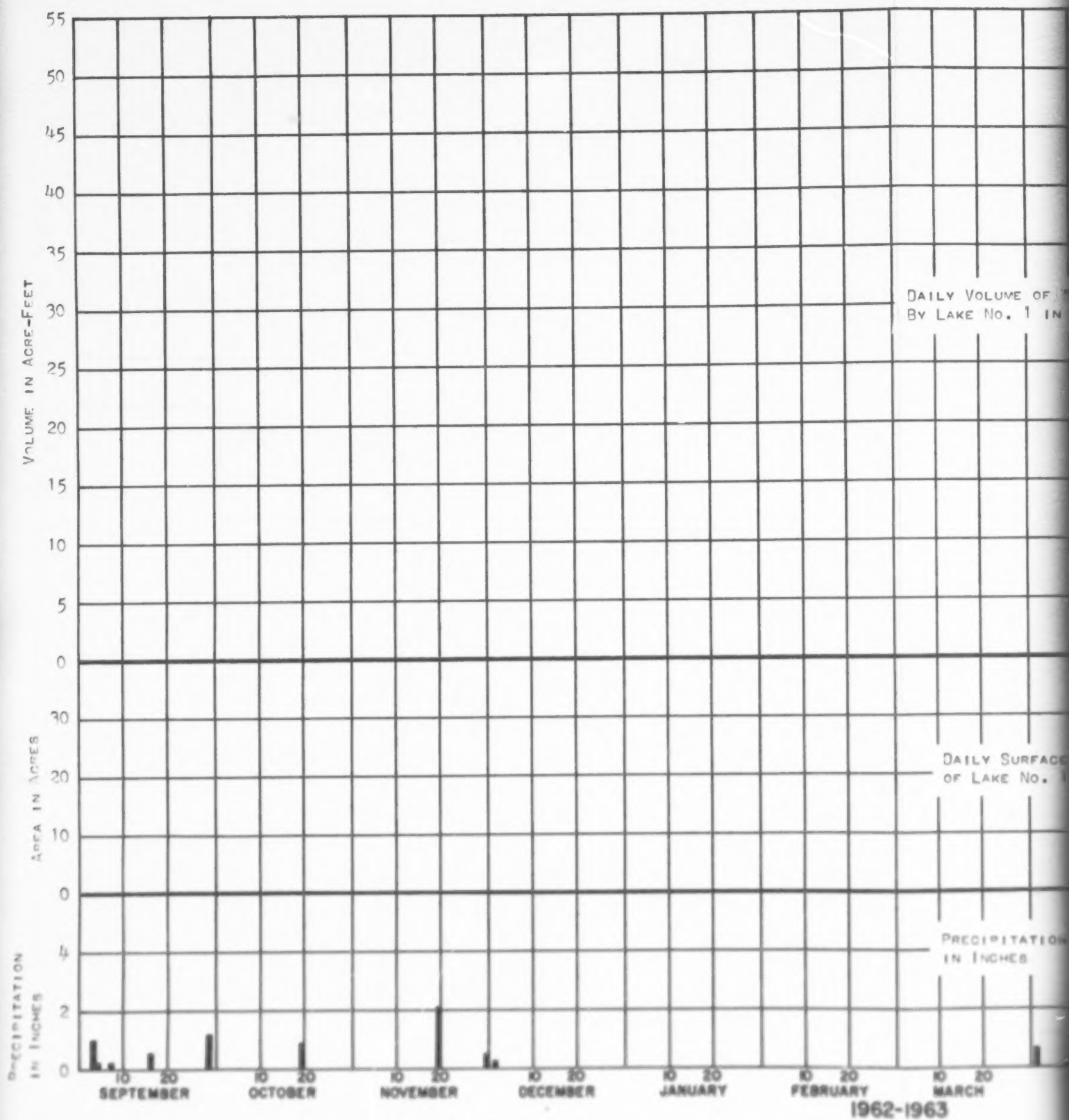


FIGURE 2. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE

DAILY VOLUME OF WATER CONTAINED  
BY LAKE No. 1 IN ACRE-Feet

DAILY SURFACE AREA  
OF LAKE No. 1 IN ACRES

PRECIPITATION AT LAKE No. 1  
IN INCHES

10 20 10 20 10 20 10 20 10 20 10 20 10 20  
FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST

1962-1963

LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE No. 1 (HUCKABEE).

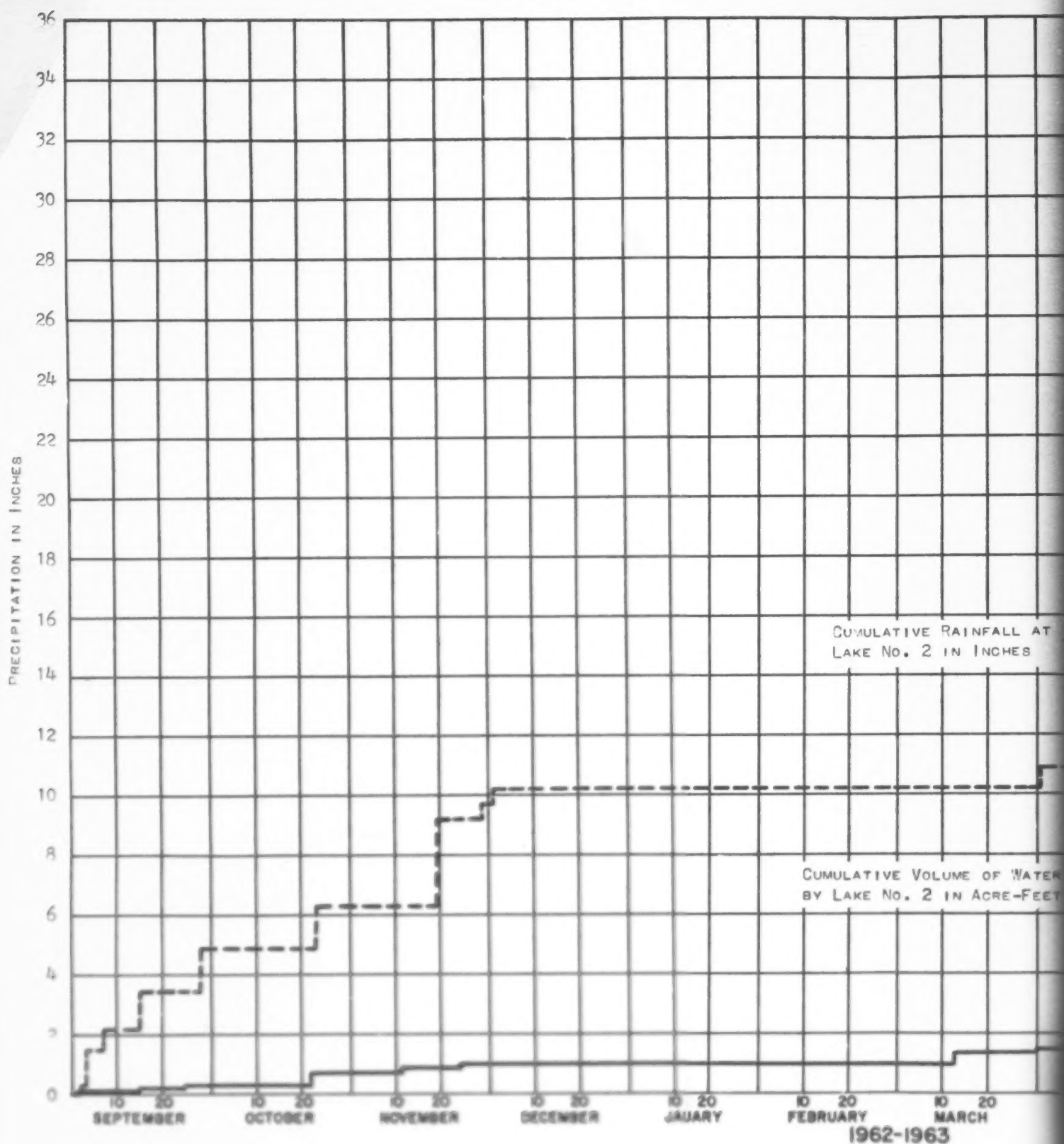


FIGURE 3. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER





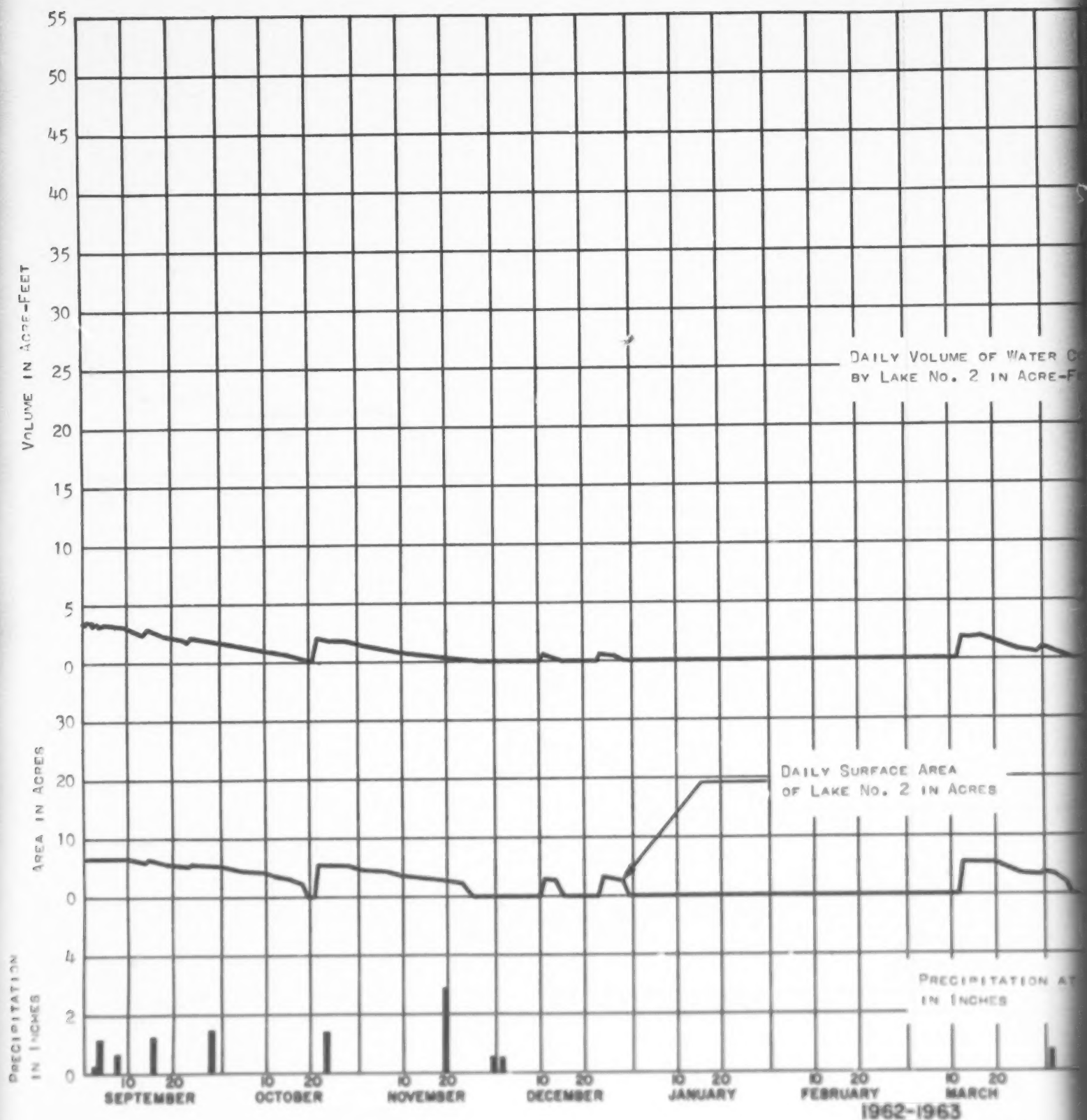


FIGURE 4. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE

DAILY VOLUME OF WATER CONTAINED  
BY LAKE NO. 2 IN ACRE-FEET

DAILY SURFACE AREA  
OF LAKE NO. 2 IN ACRES

PRECIPITATION AT LAKE NO. 2  
IN INCHES

10 20 10 20 10 20 10 20 10 20 10 20 10 20  
FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST

1962-1963

BY LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE NO. 2 (KNOWLES).

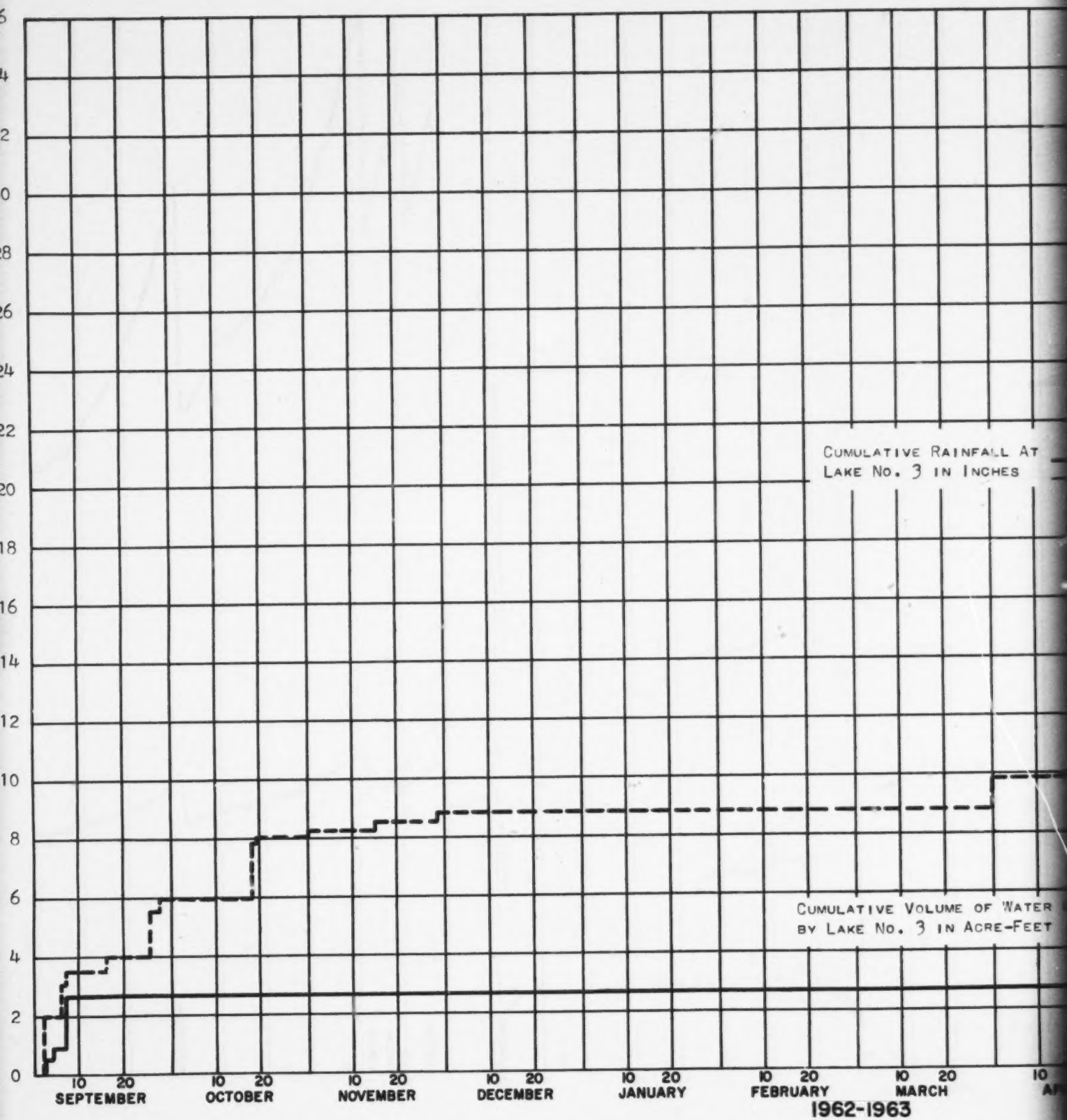
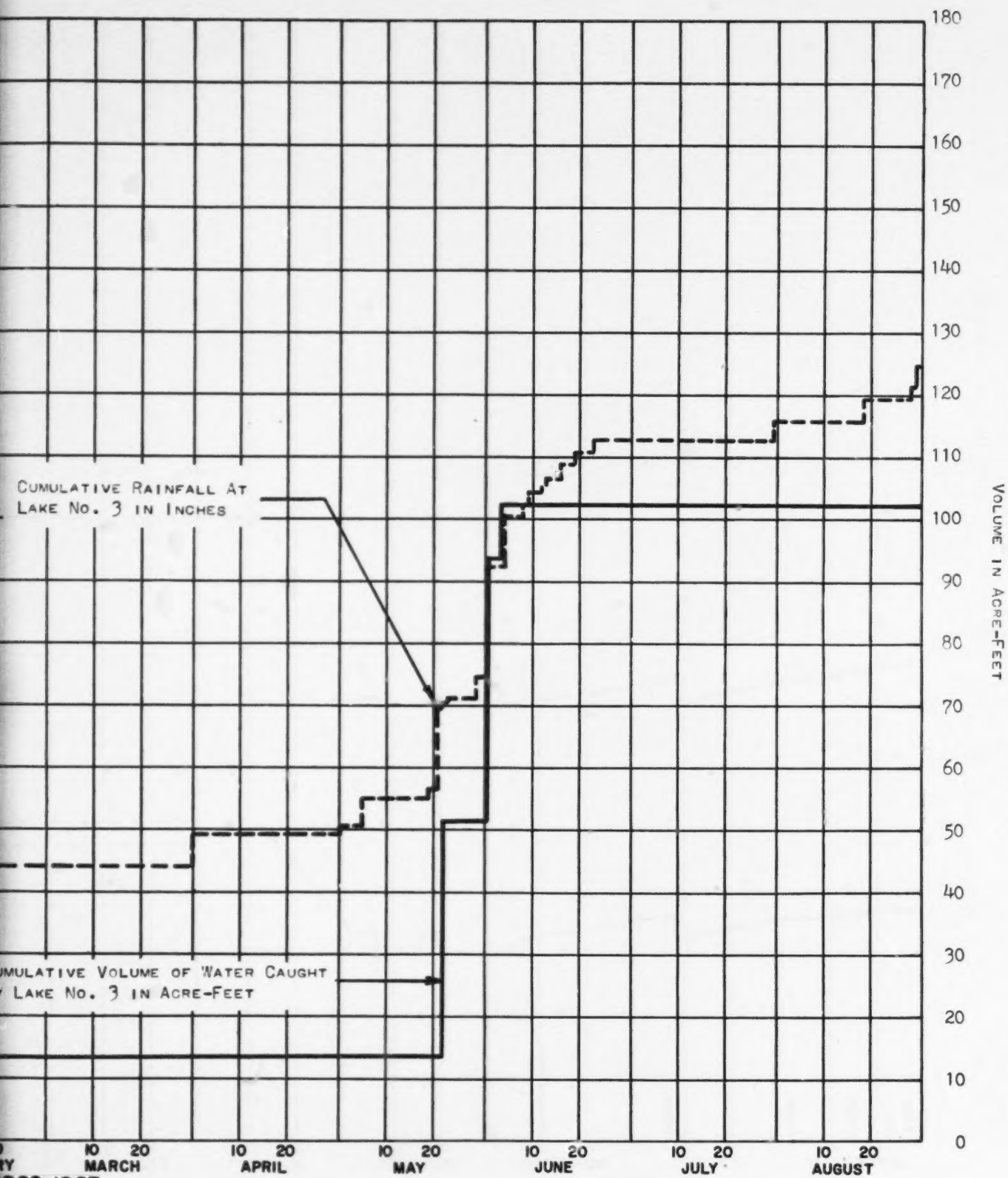


FIGURE 5. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER CAUGHT



VOLUME OF WATER CAUGHT BY LAKE NO. 3 (HUFSTEDLER).



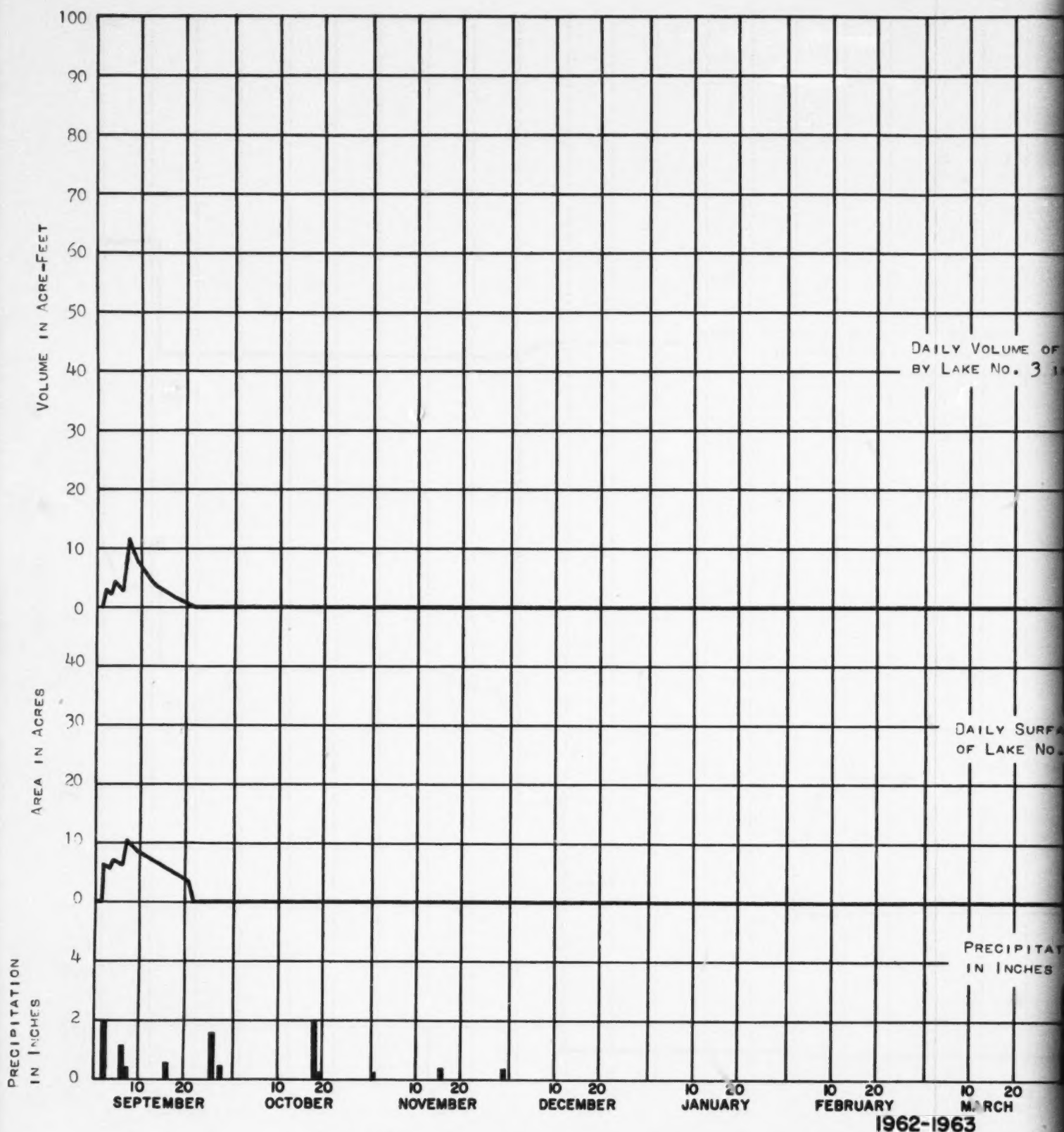
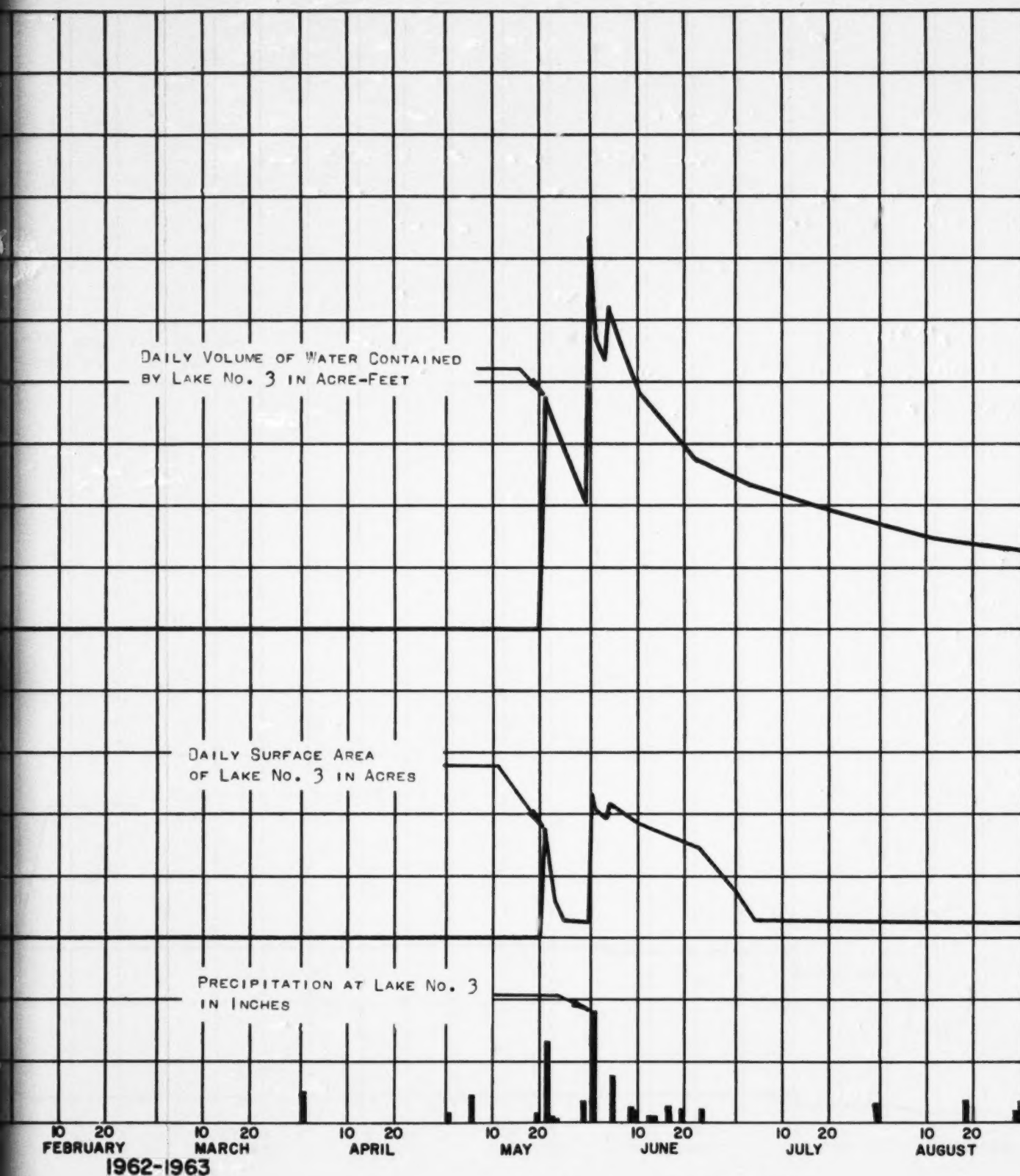


FIGURE 6. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE



LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE NO. 3 (HUFSTEDLER).

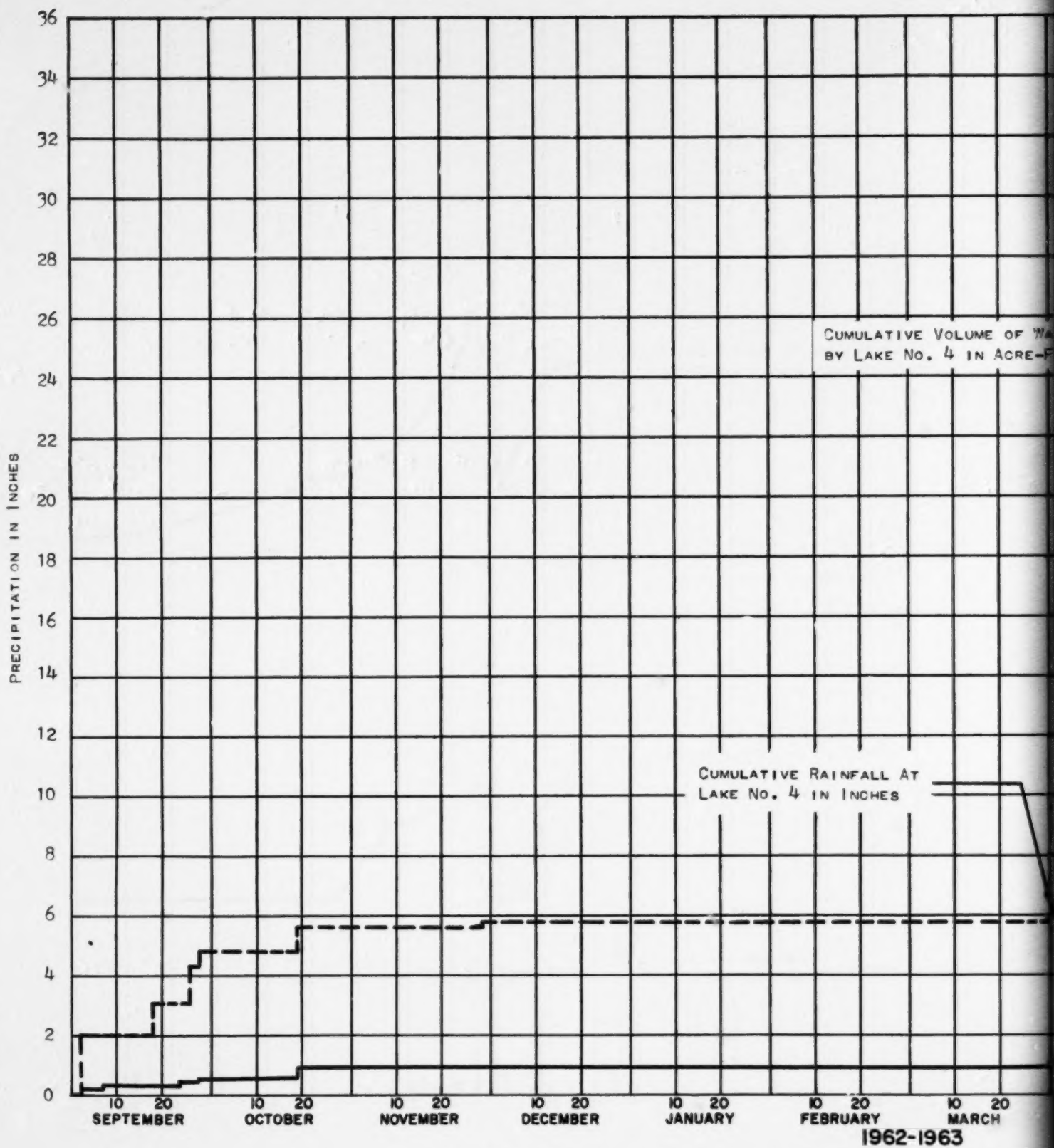
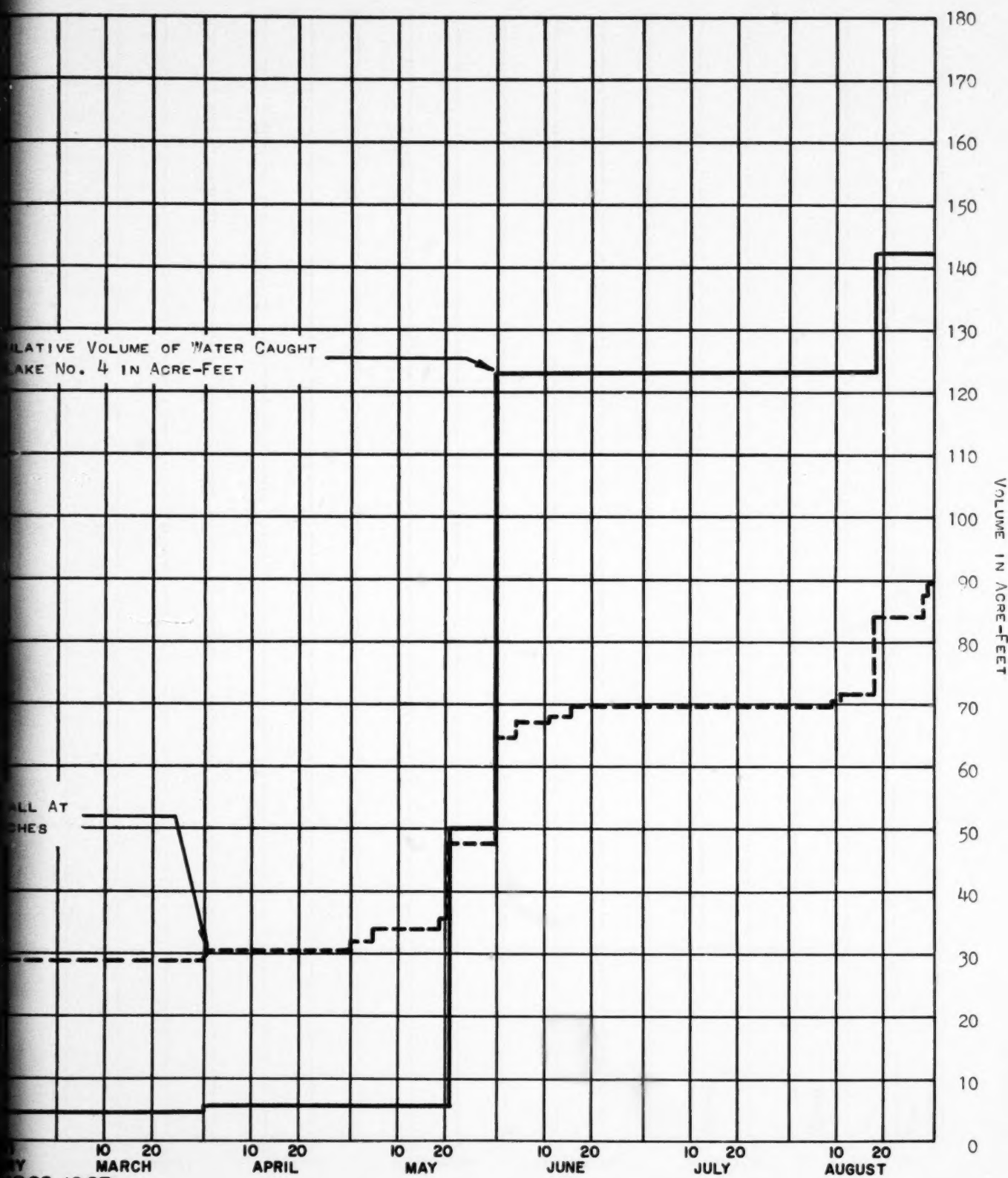


FIGURE 7. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER





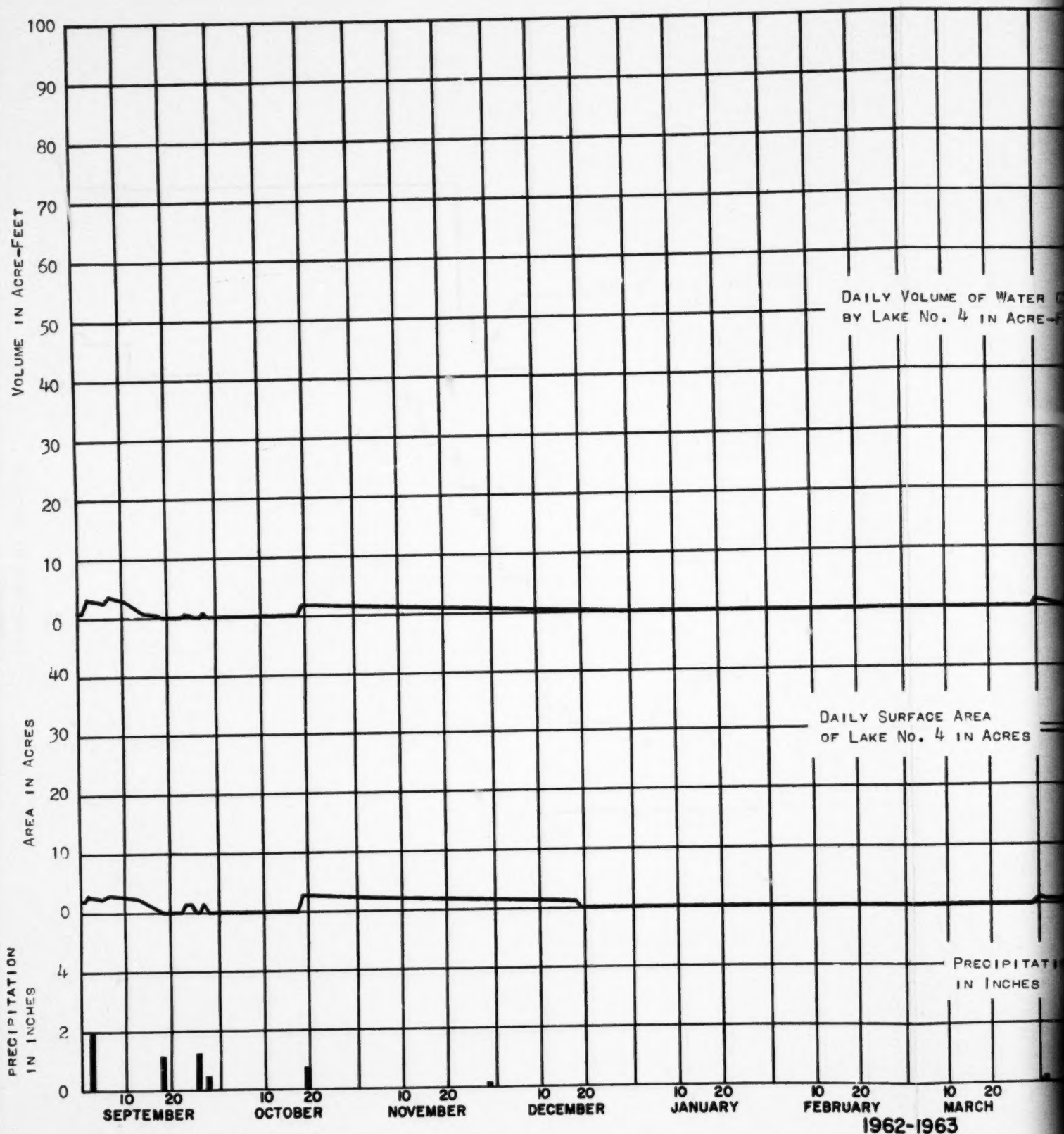
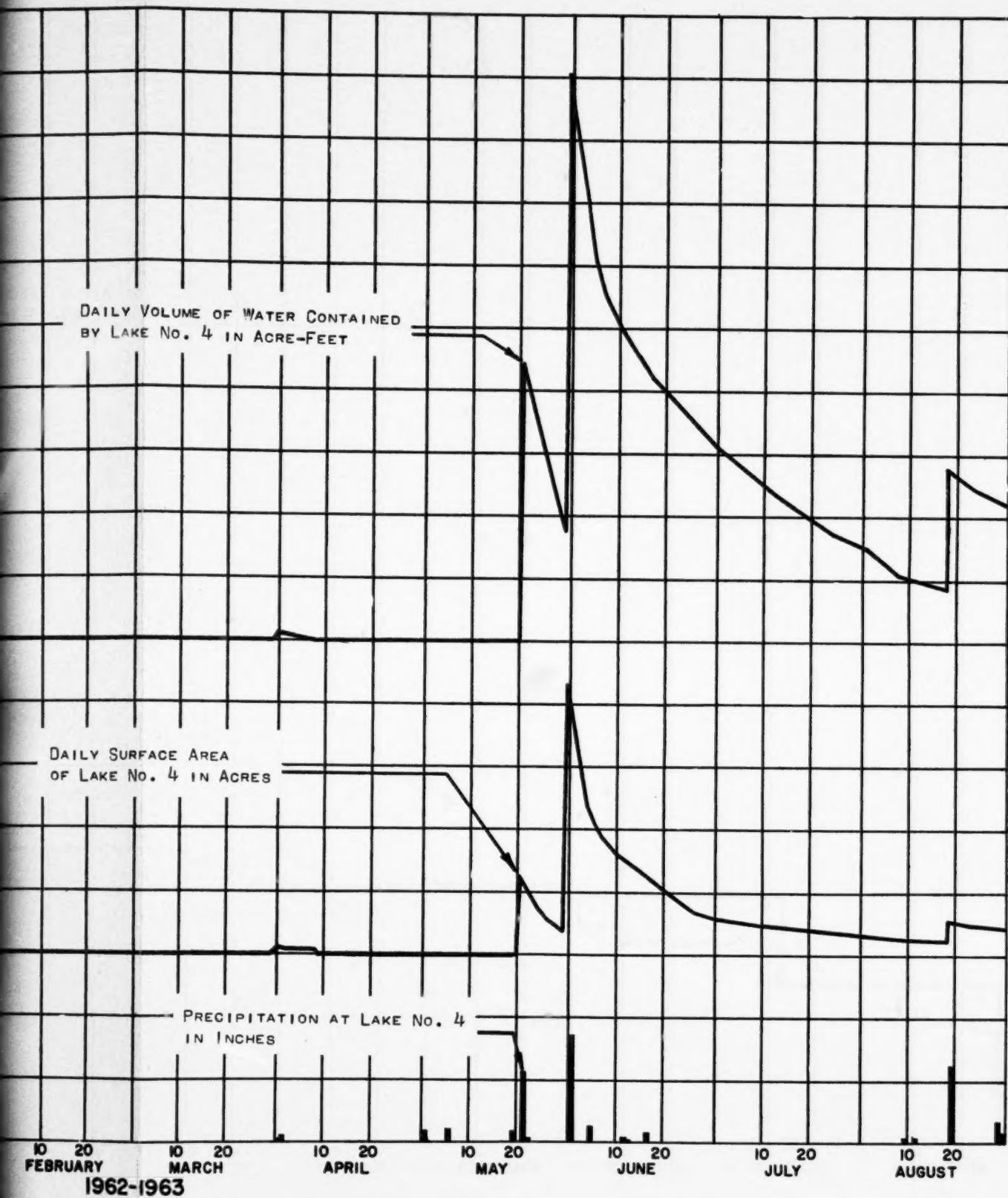


FIGURE 8. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF L



LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE NO. 4 (L.C.C.).

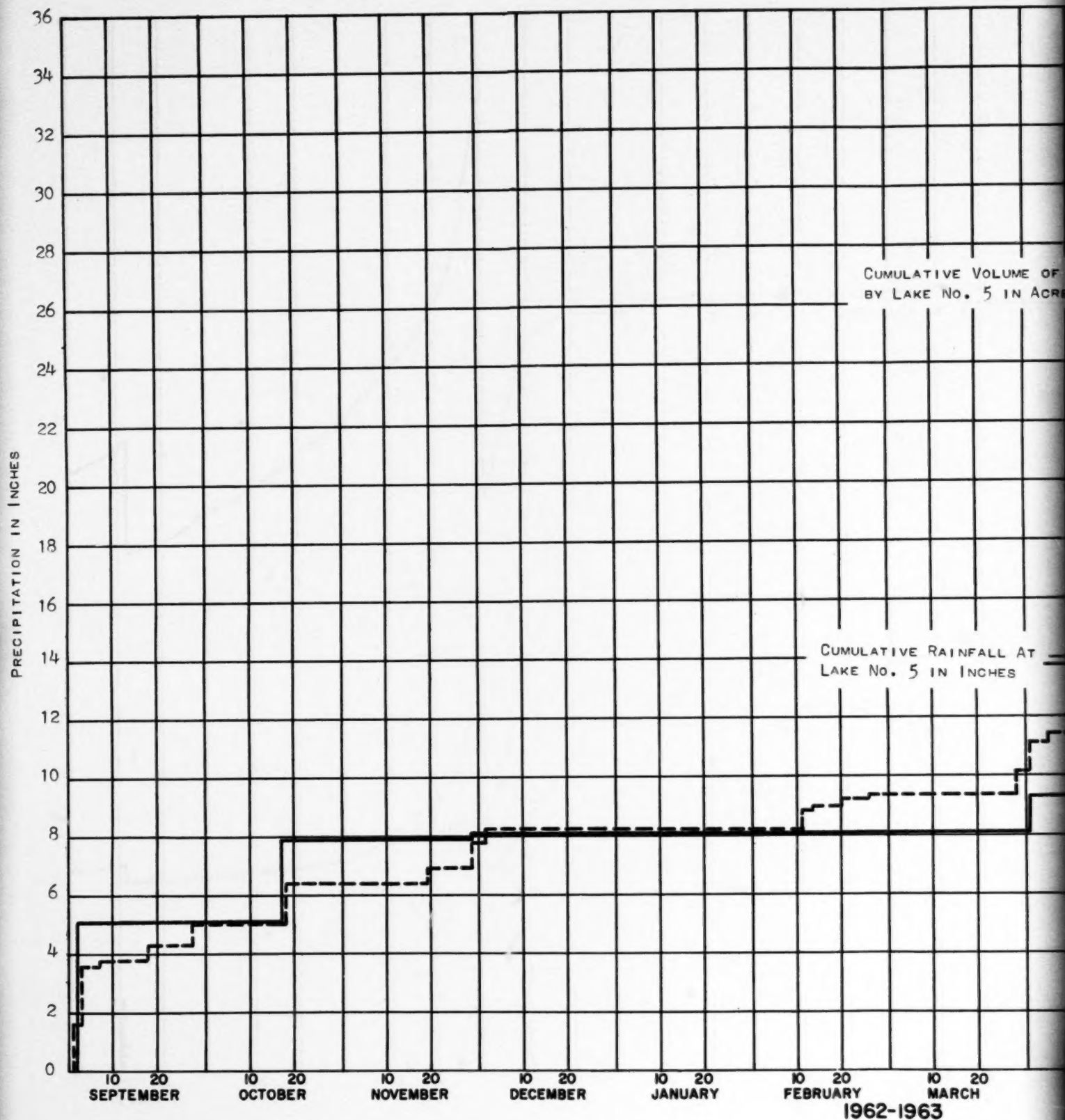


FIGURE 9. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER





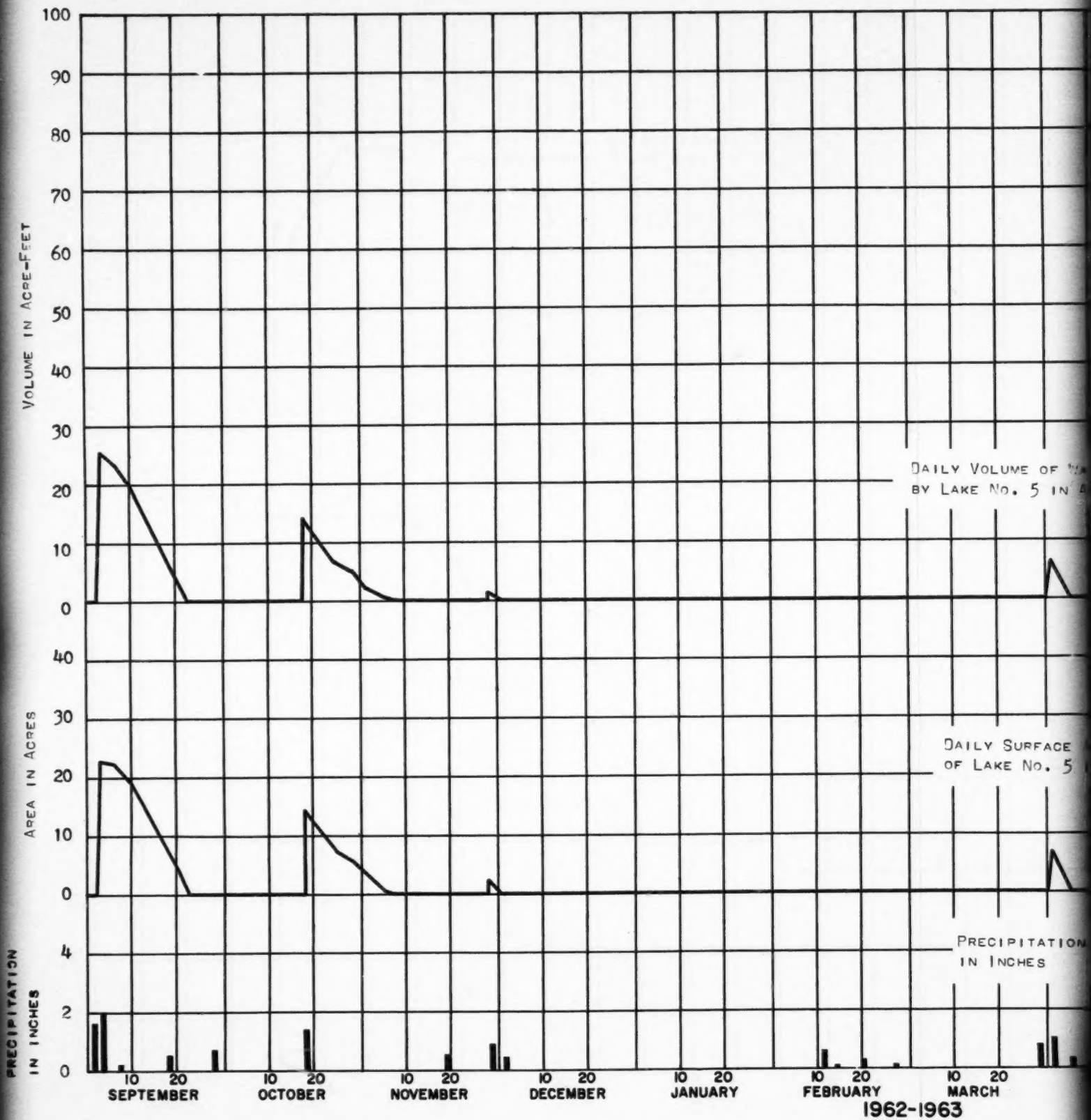
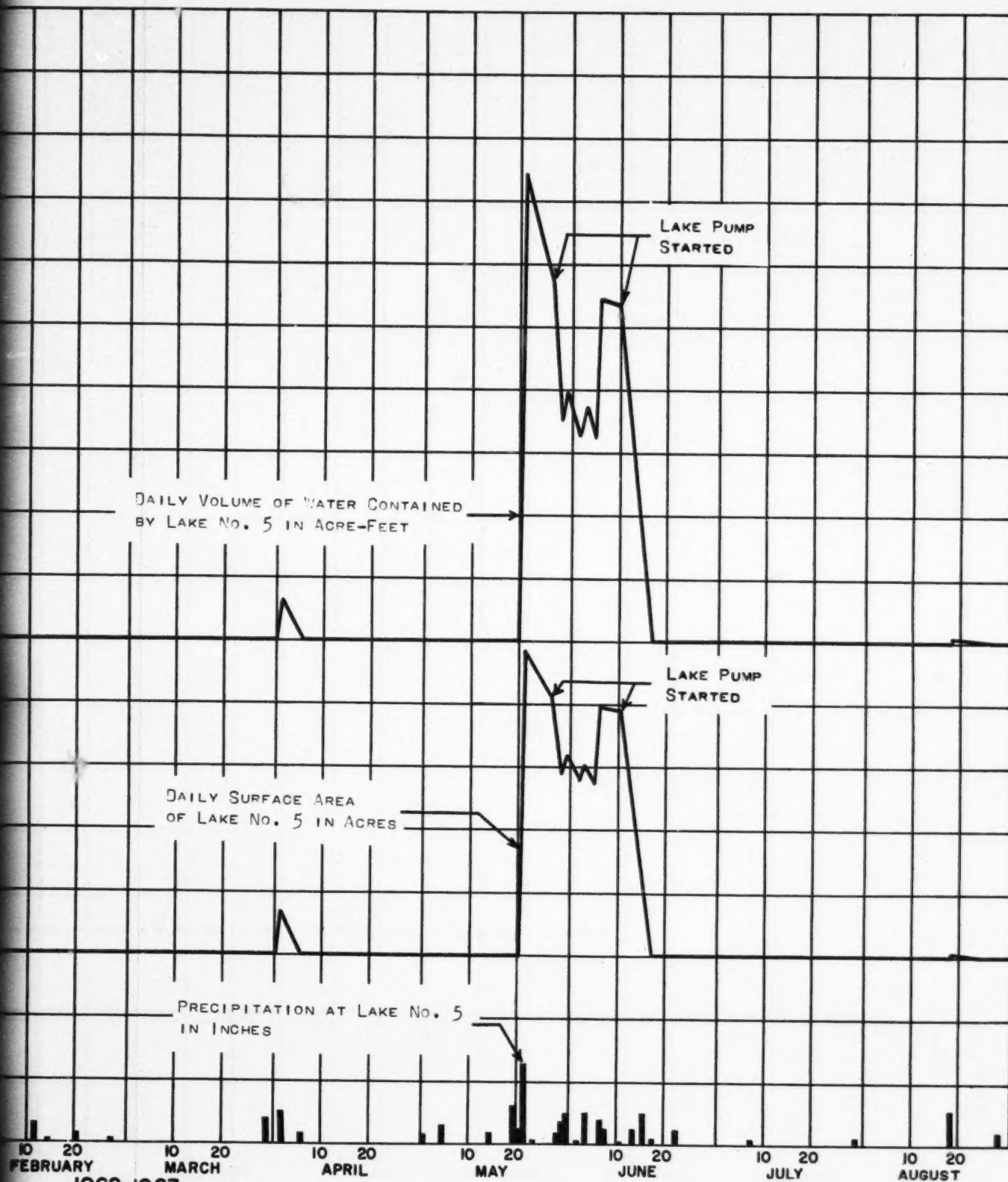


FIGURE 10. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE



LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE NO. 5 (KITTEEN).

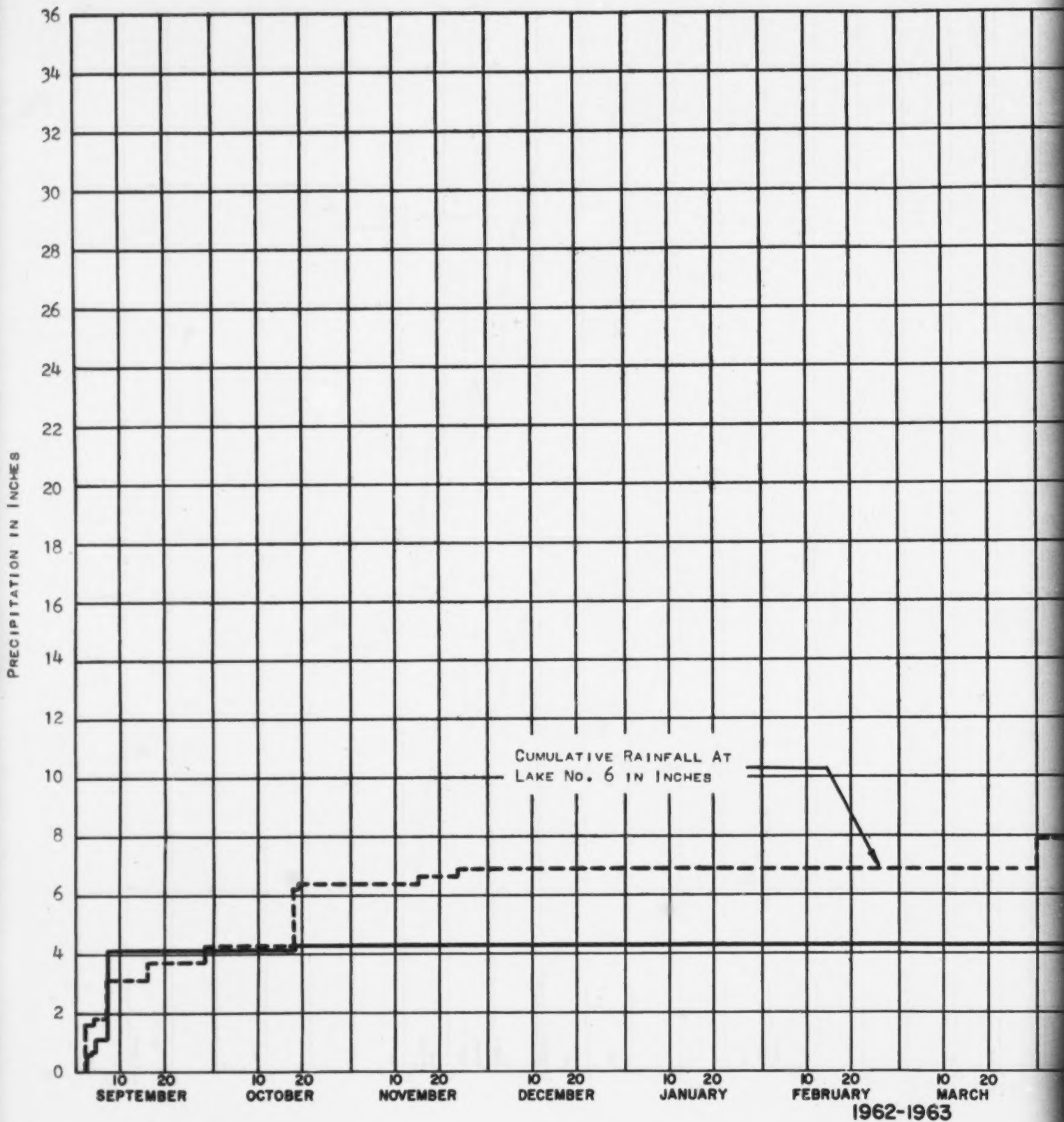


FIGURE 11. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER





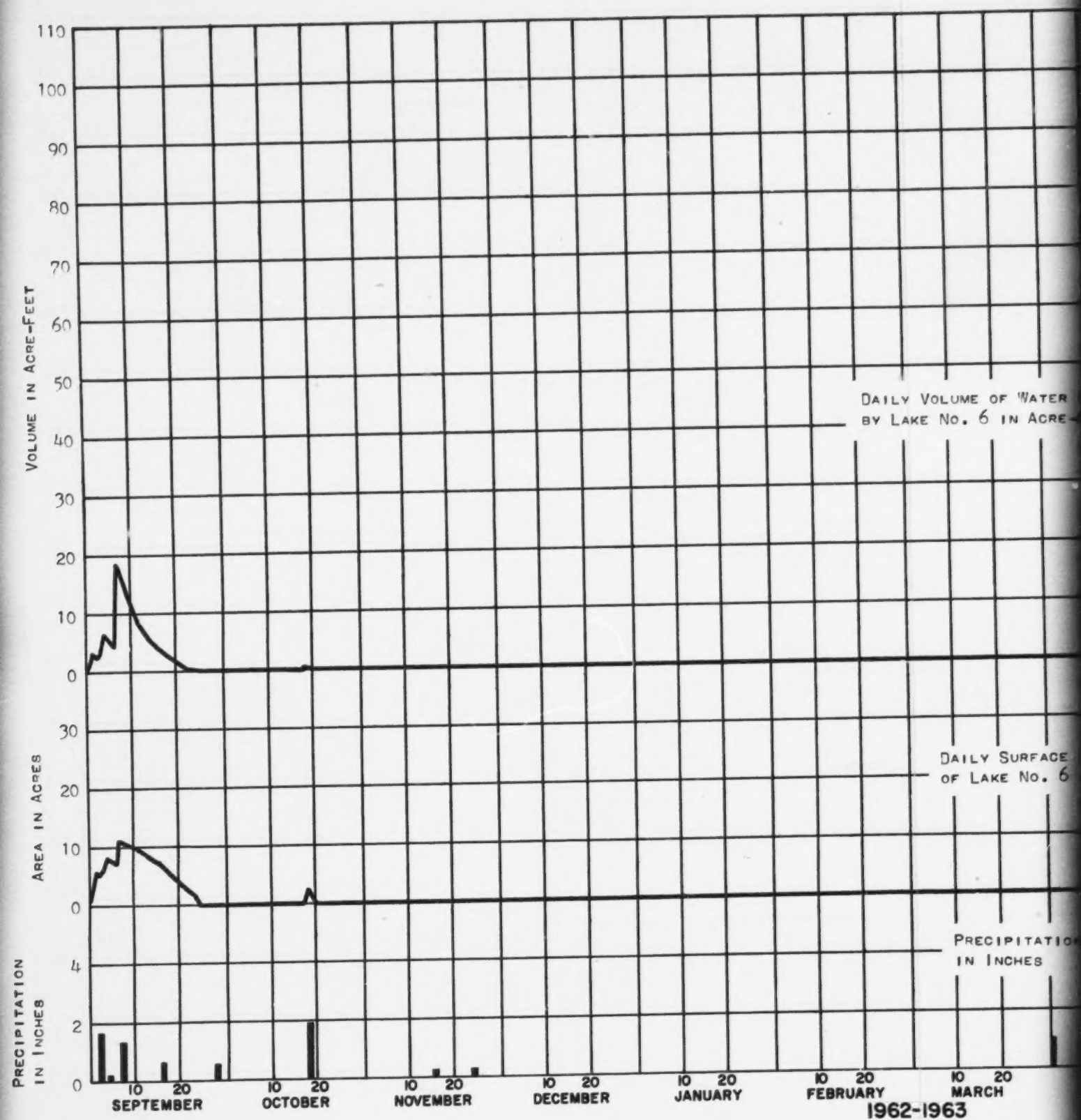
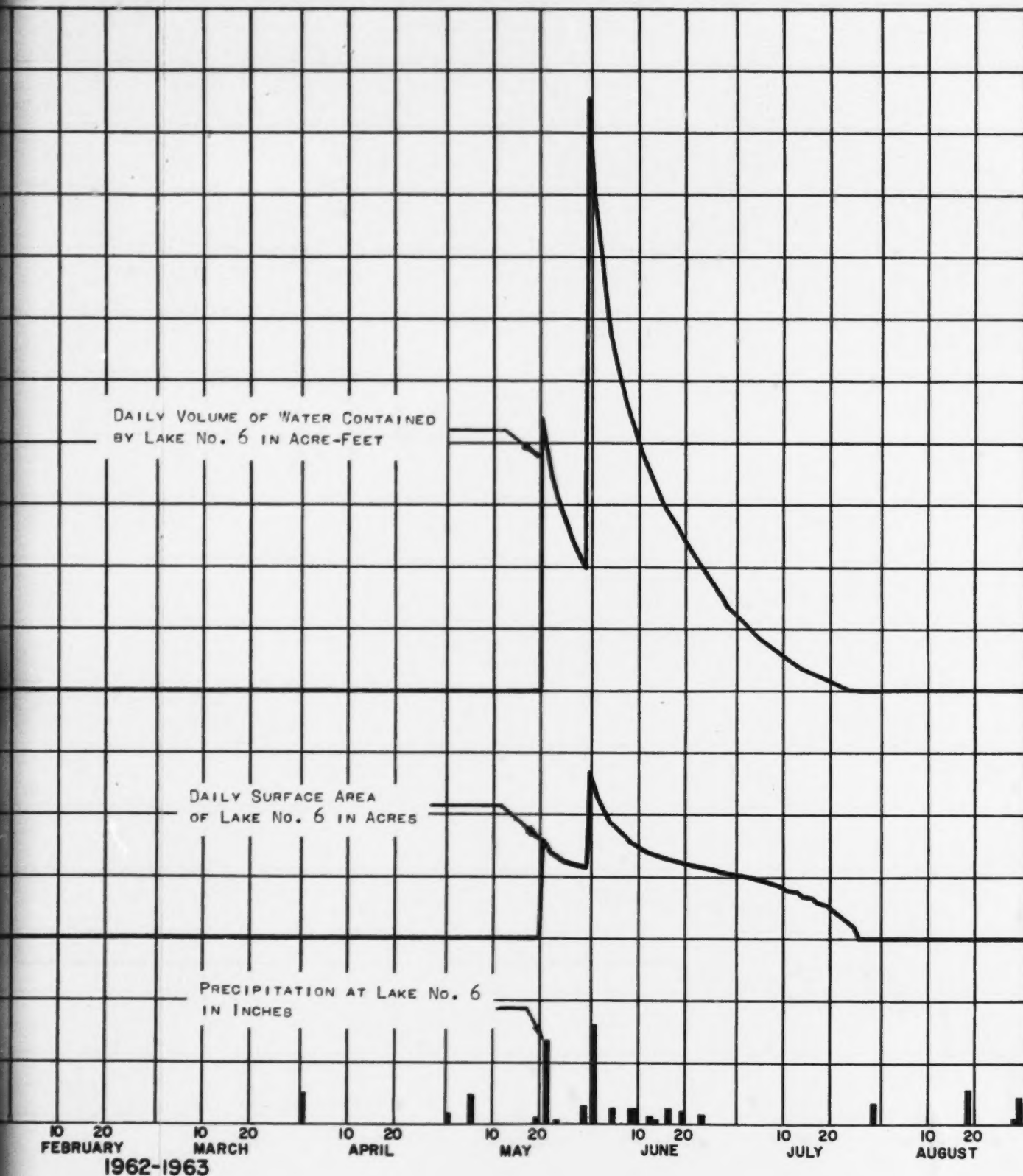


FIGURE 12. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF



BY LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE NO. 6 (HOLLAND).

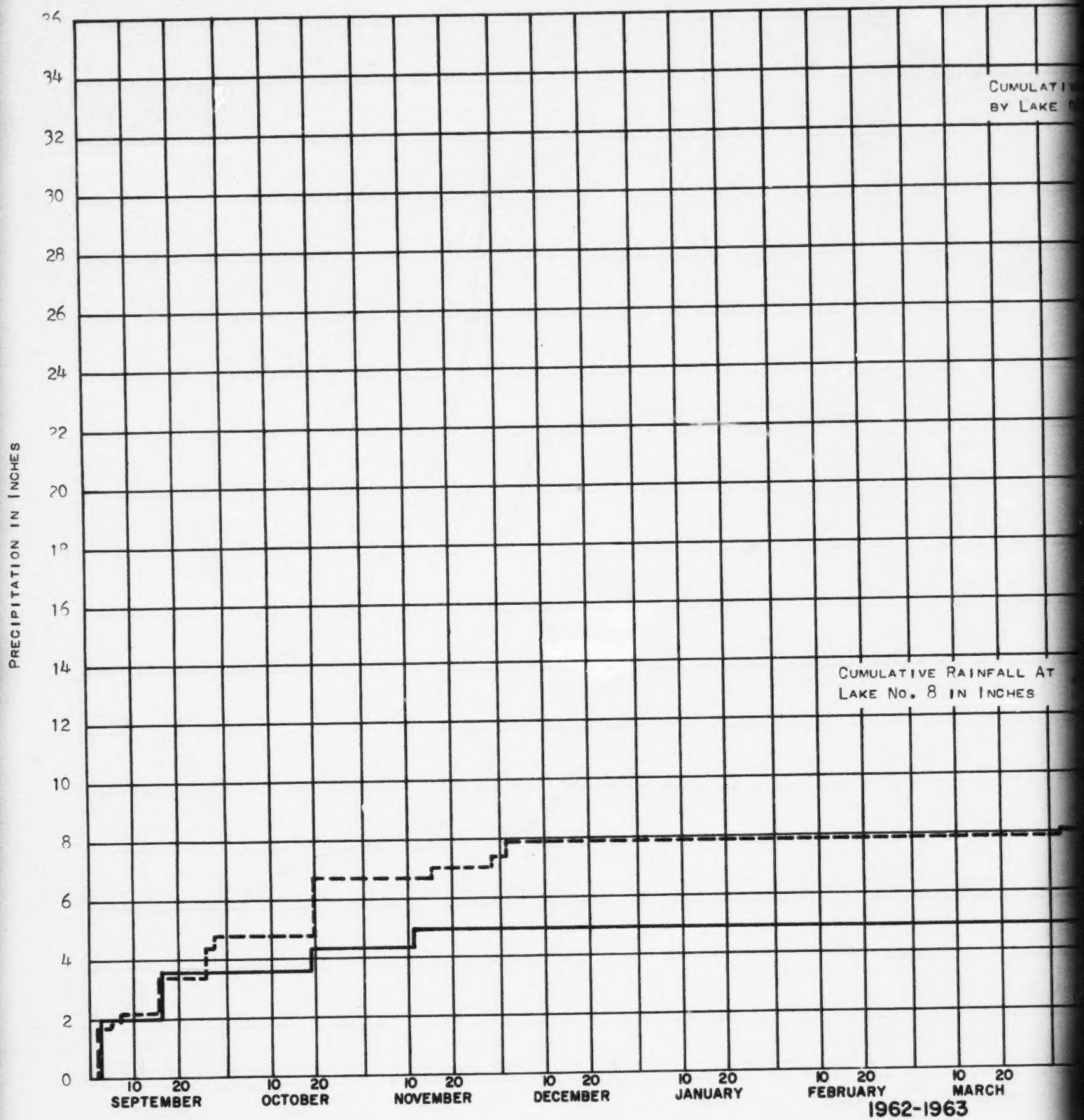
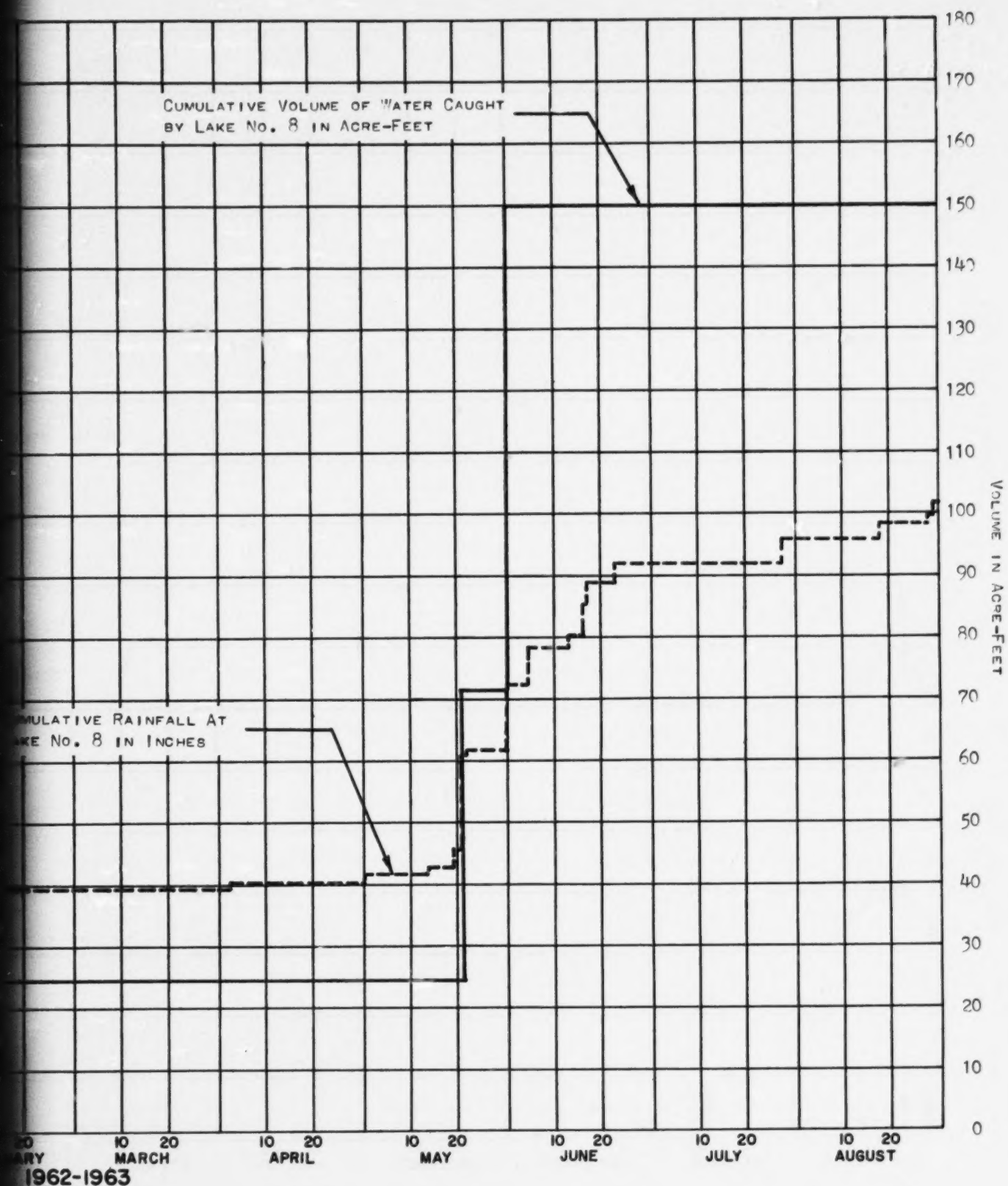


FIGURE 13. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER



CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE NO. 8 (BURGETT).



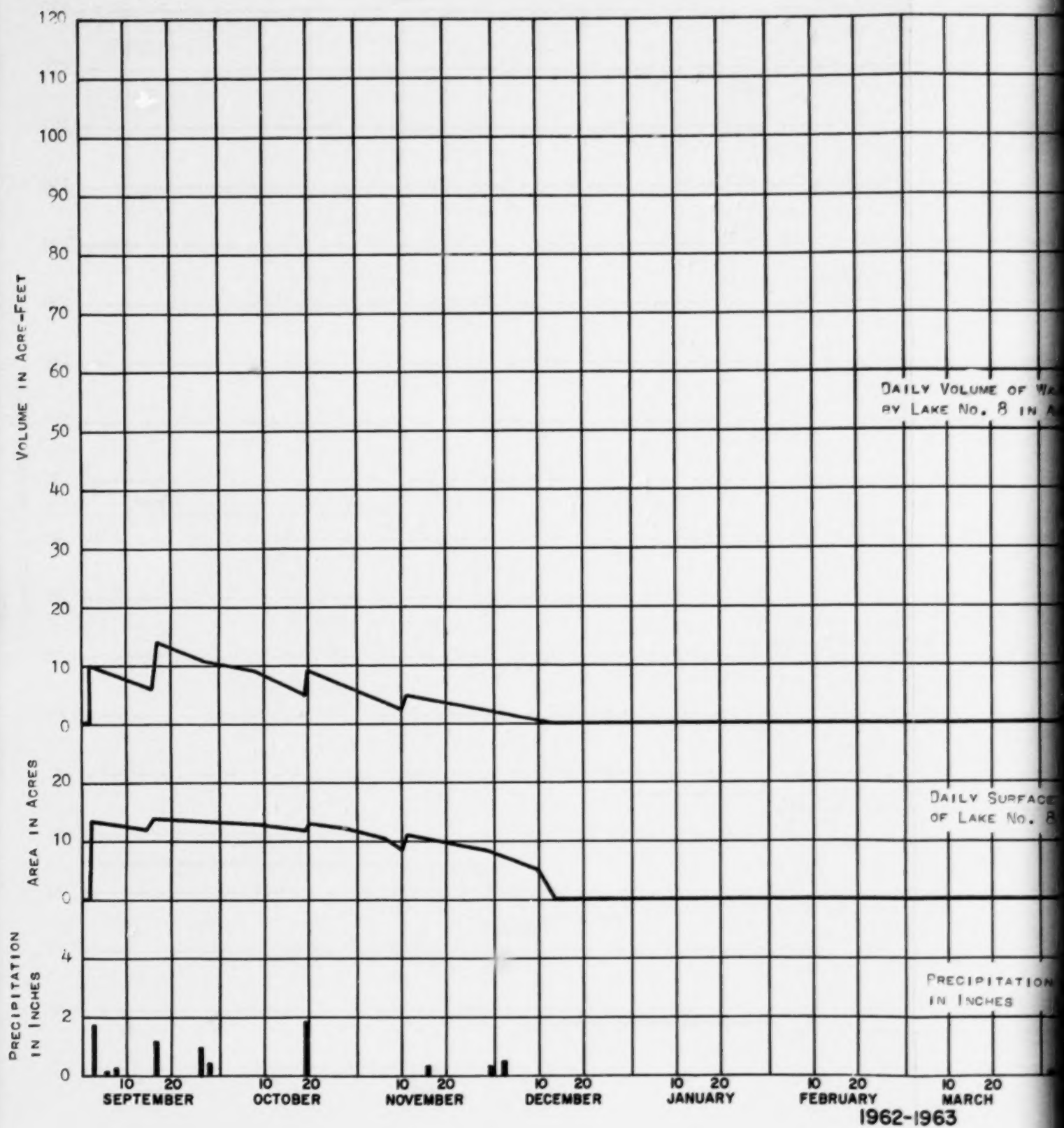
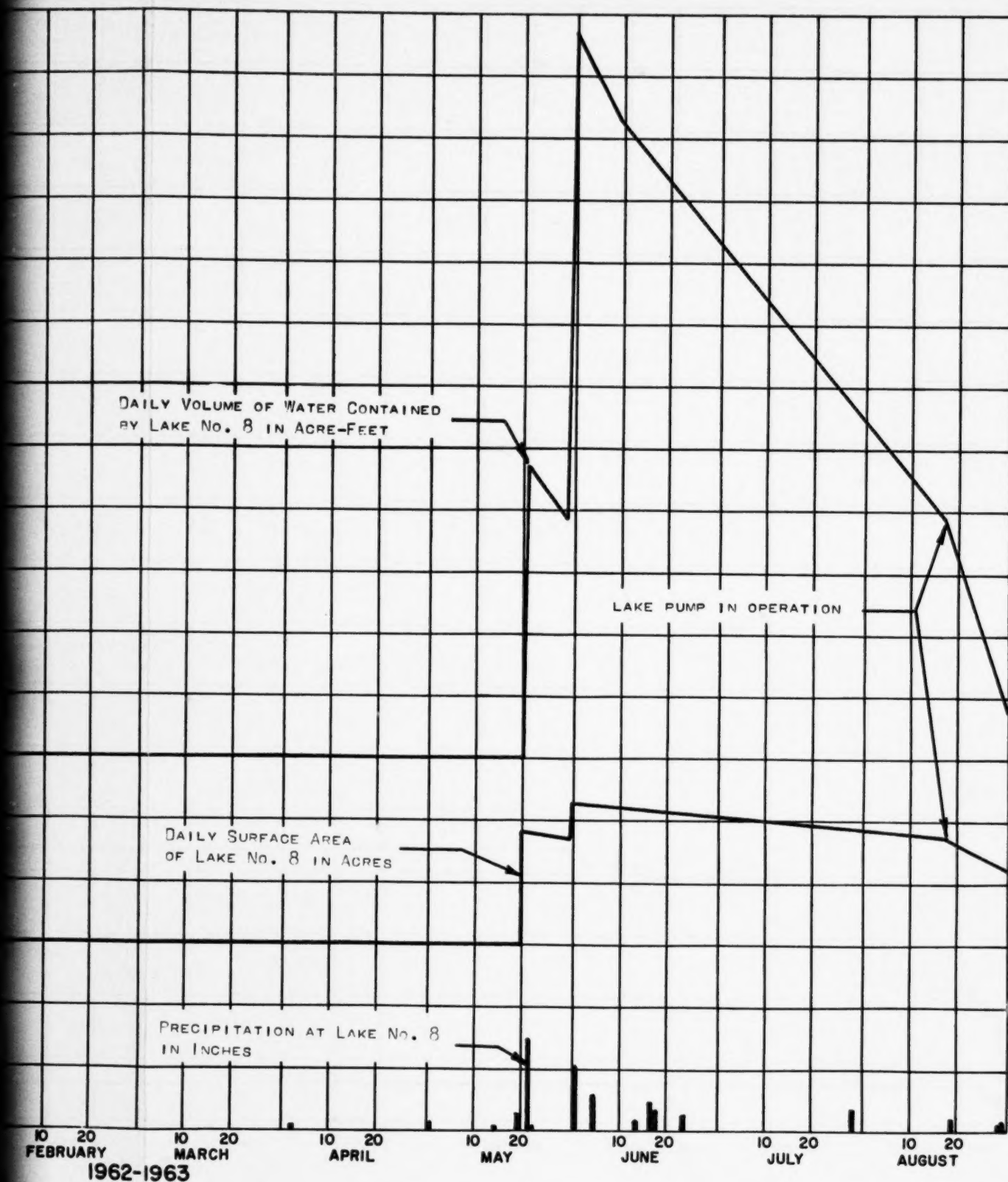


FIGURE 14. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF



LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE NO. 8 (BURGETT).

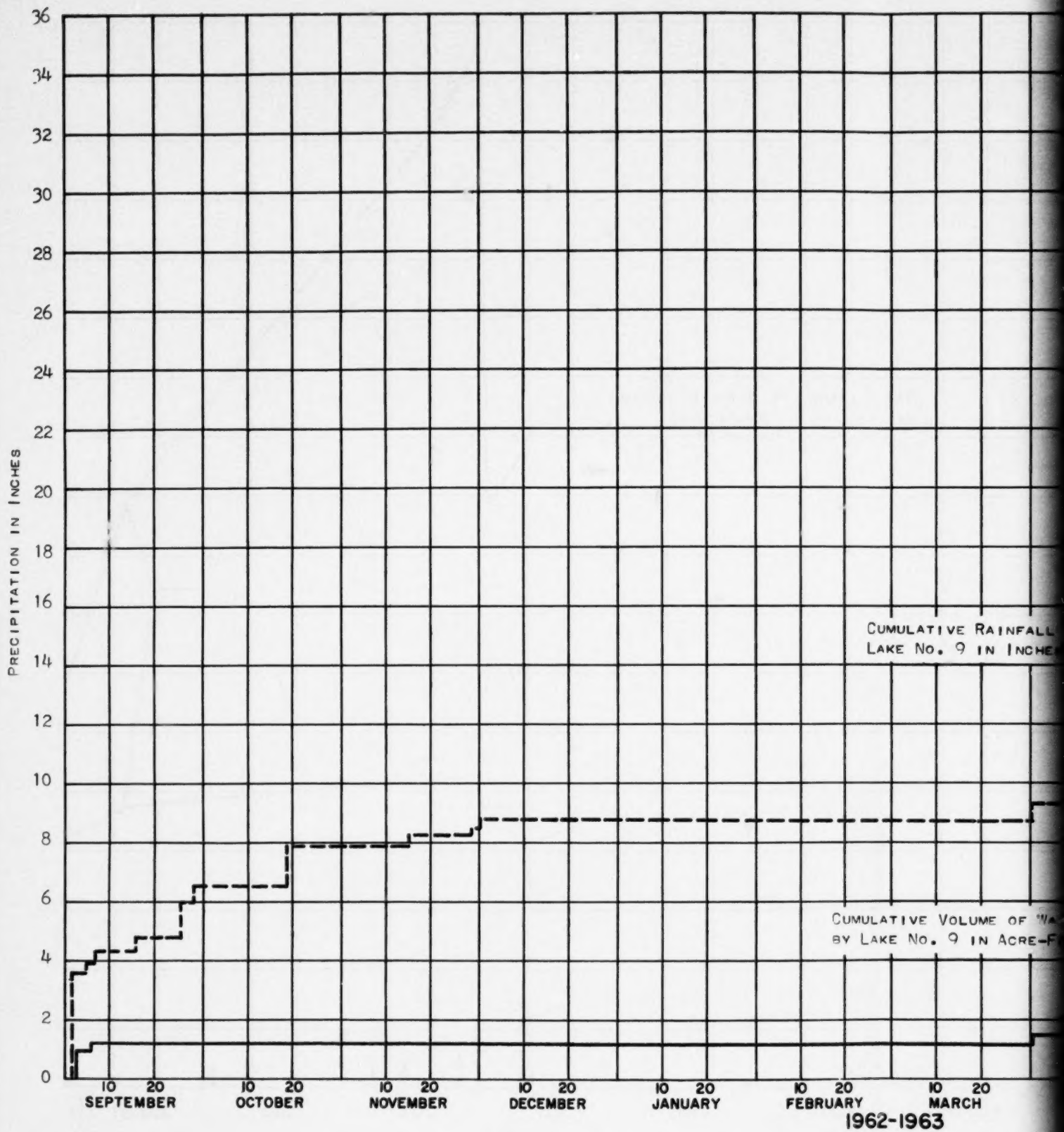
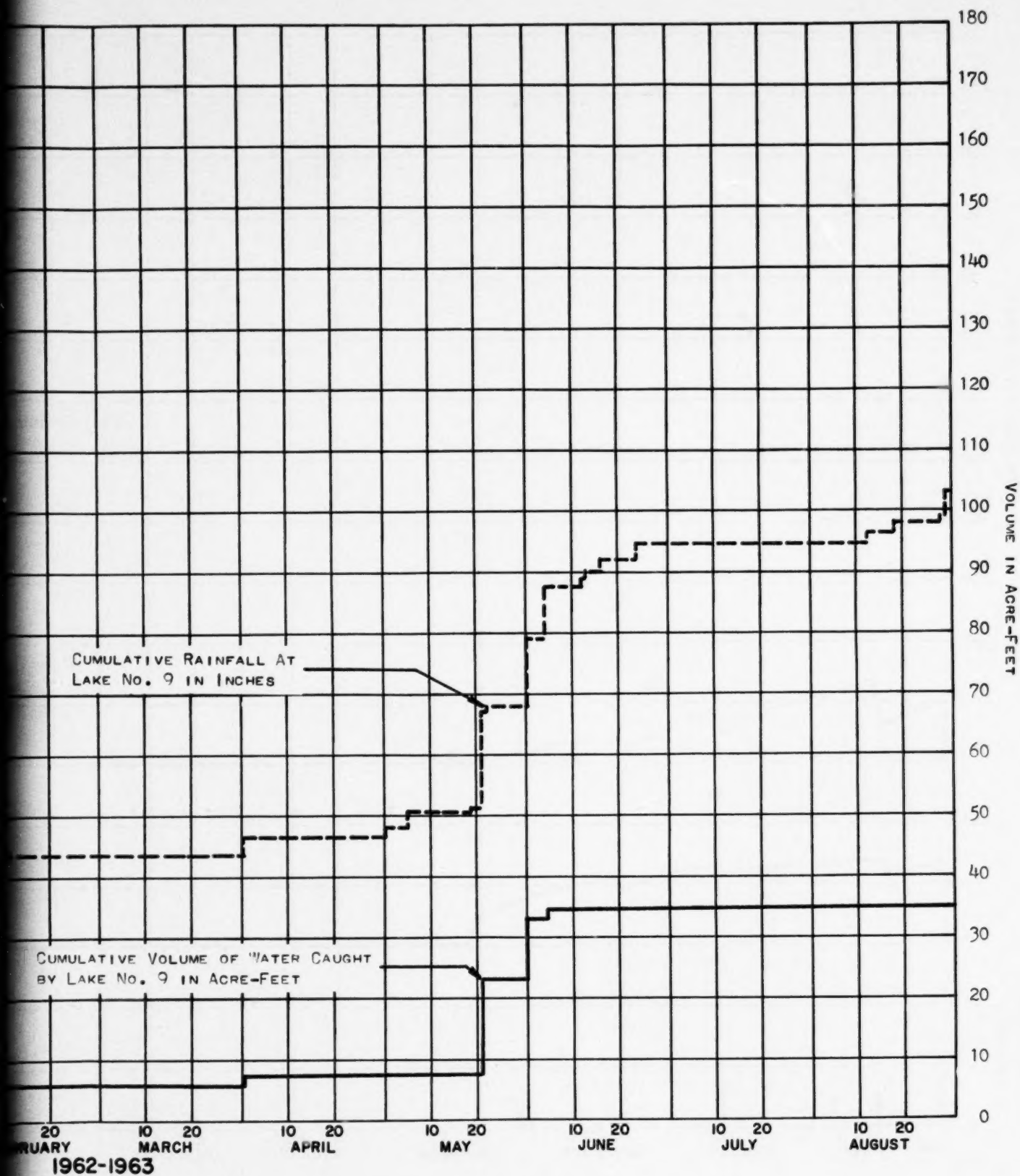


FIGURE 15. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER



CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE NO. 9 (Cox).



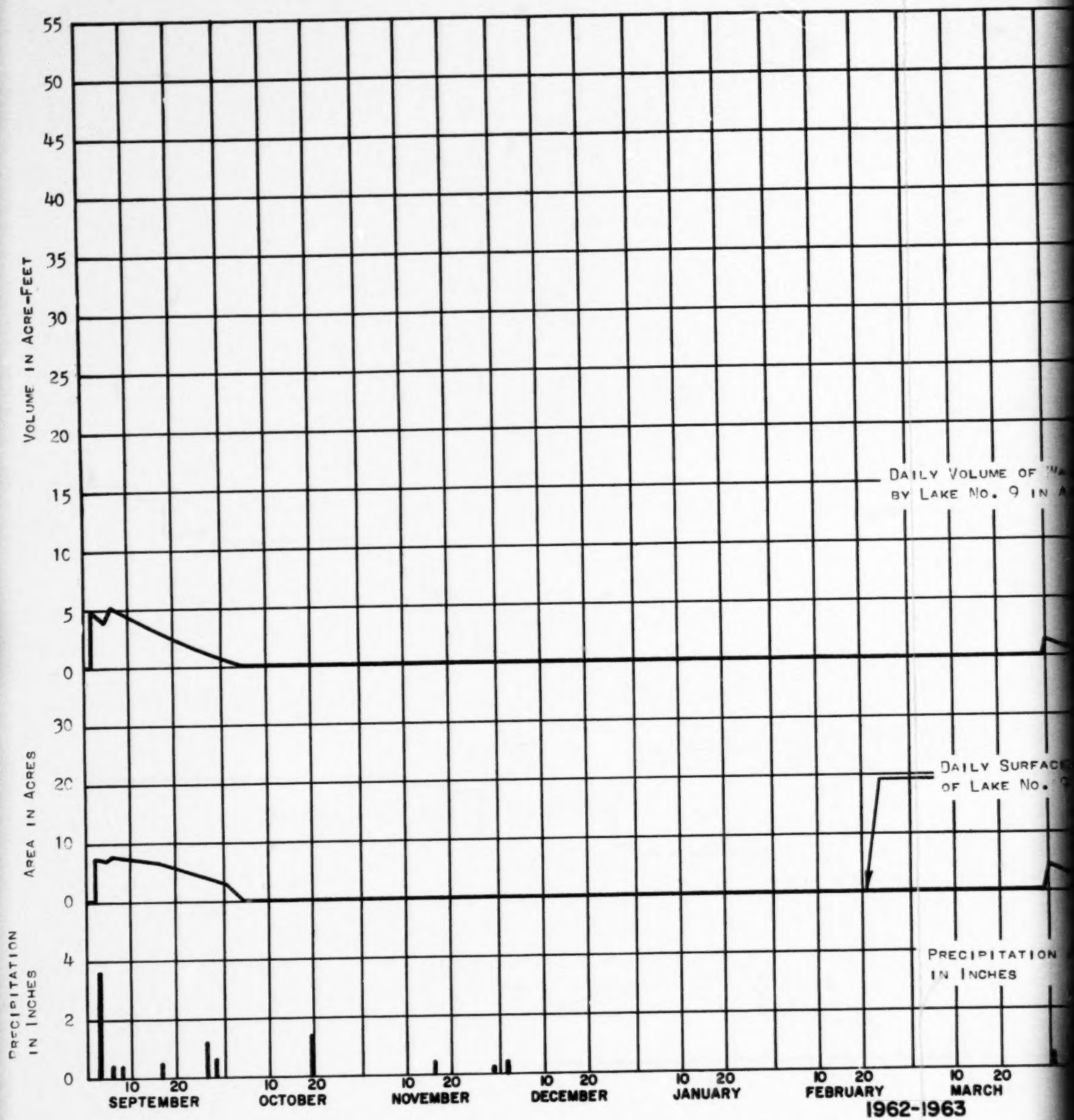
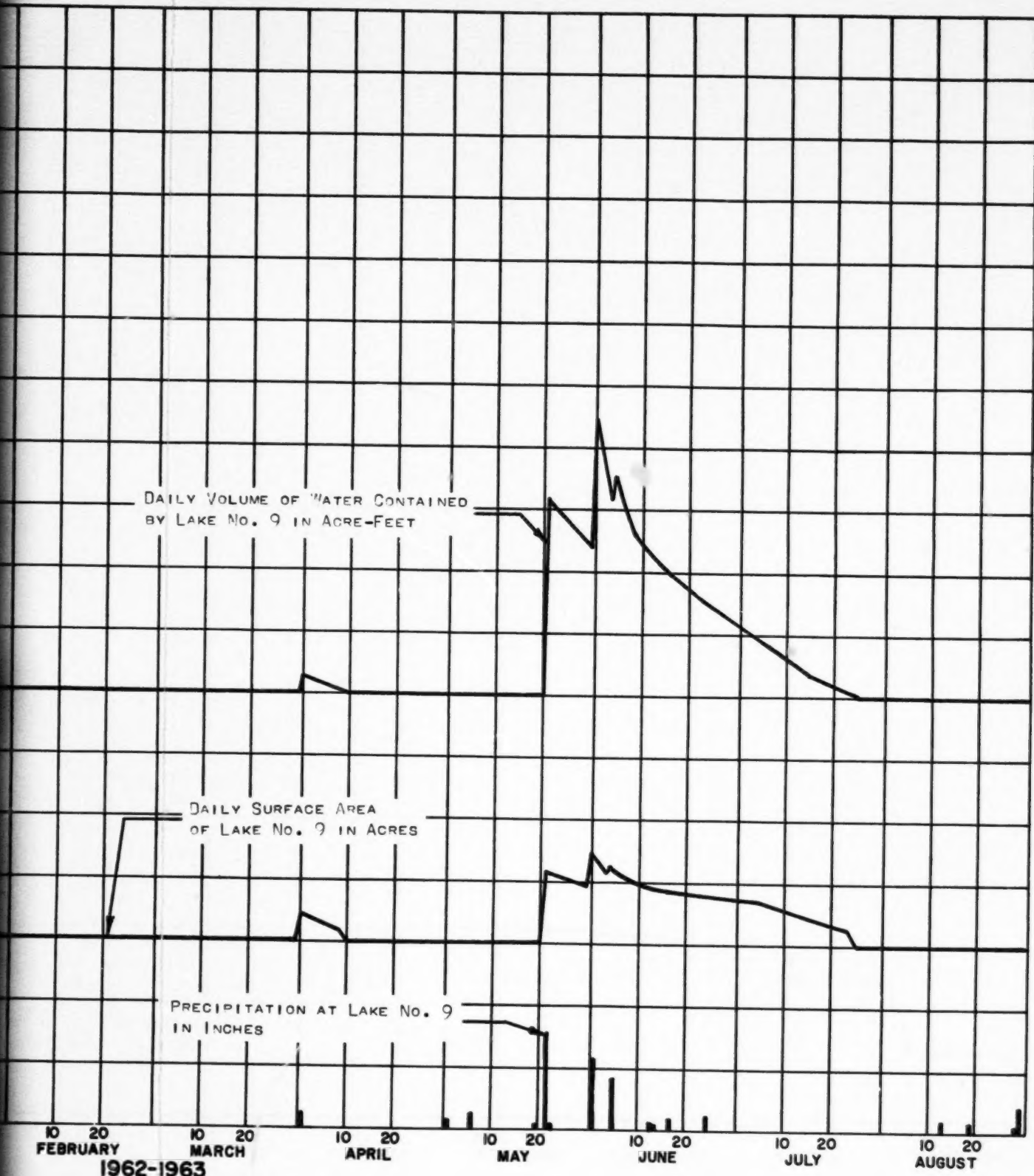


FIGURE 16. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE



LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE NO. 9 (Cox).

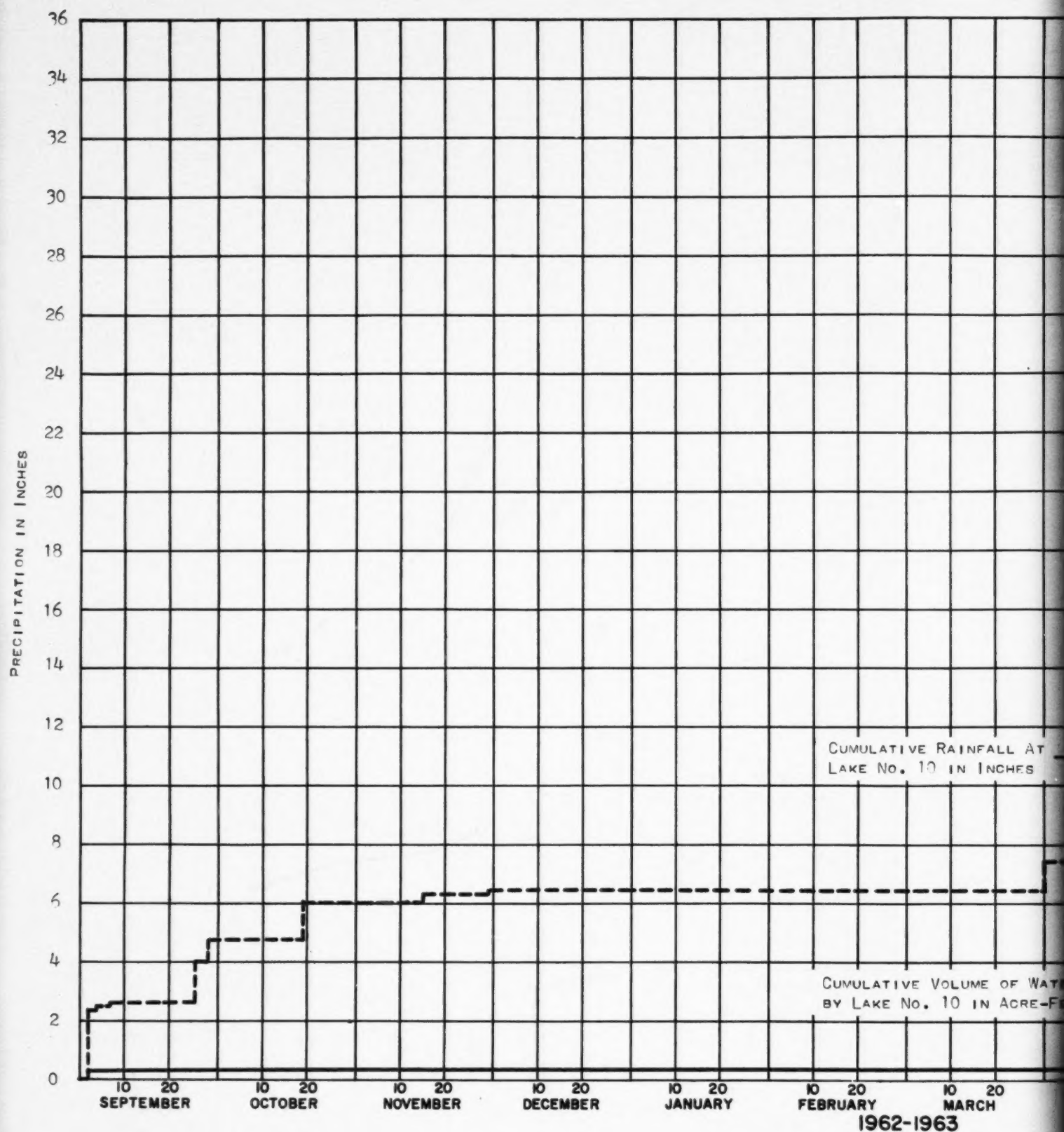
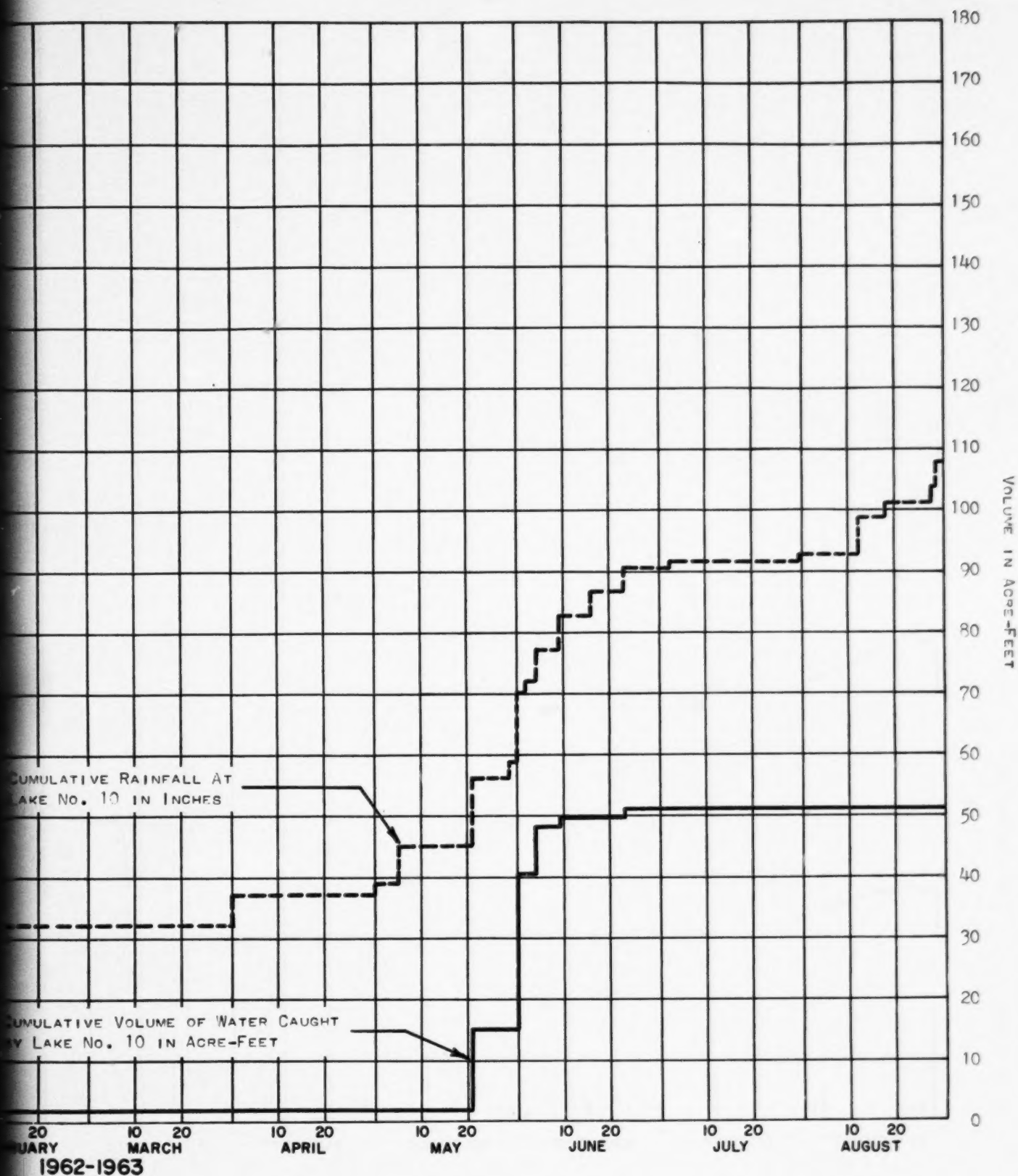


FIGURE 17. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER CAPTURED BY LAKE NO. 10



CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE NO. 10 (DUPREE).



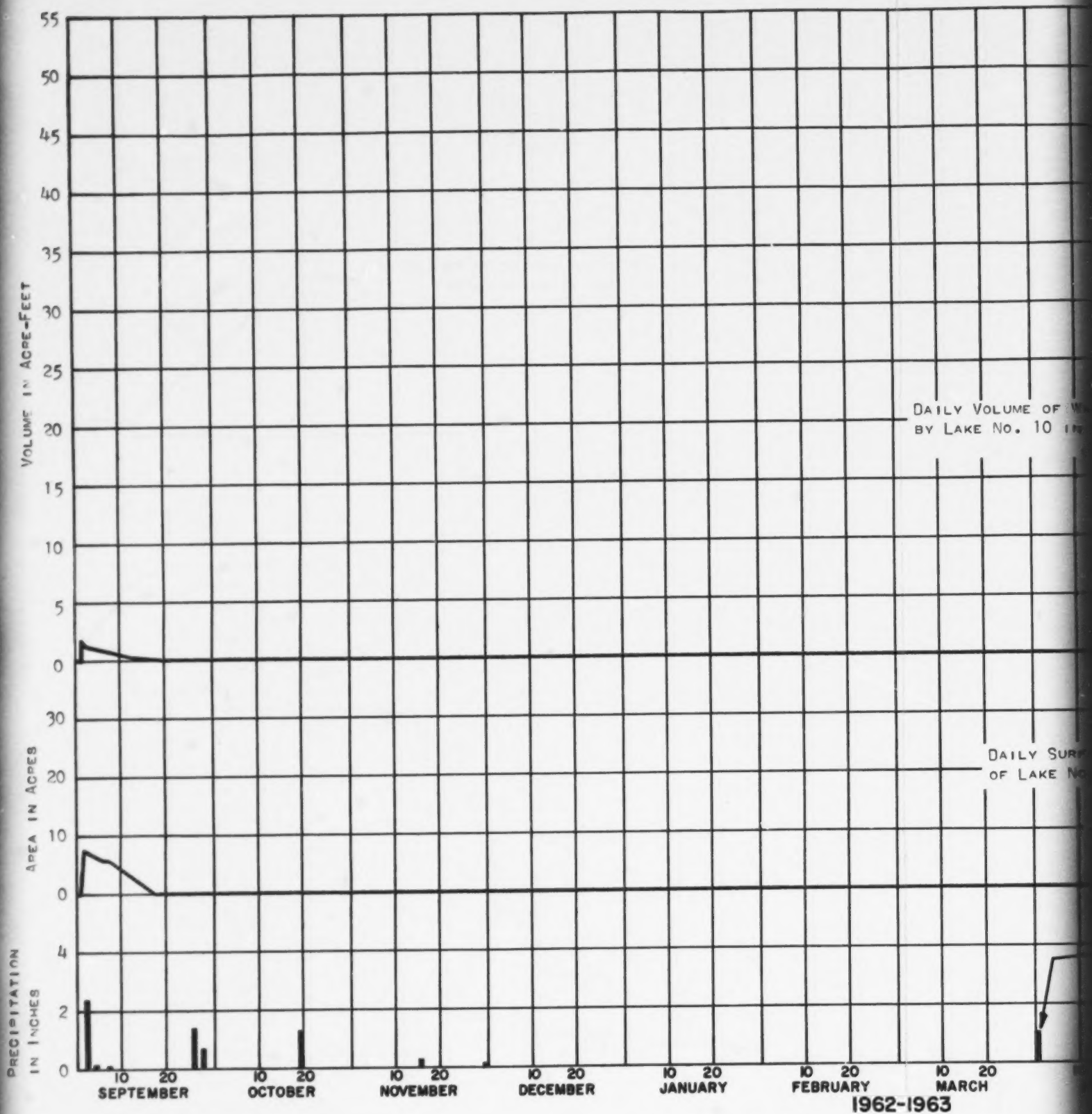
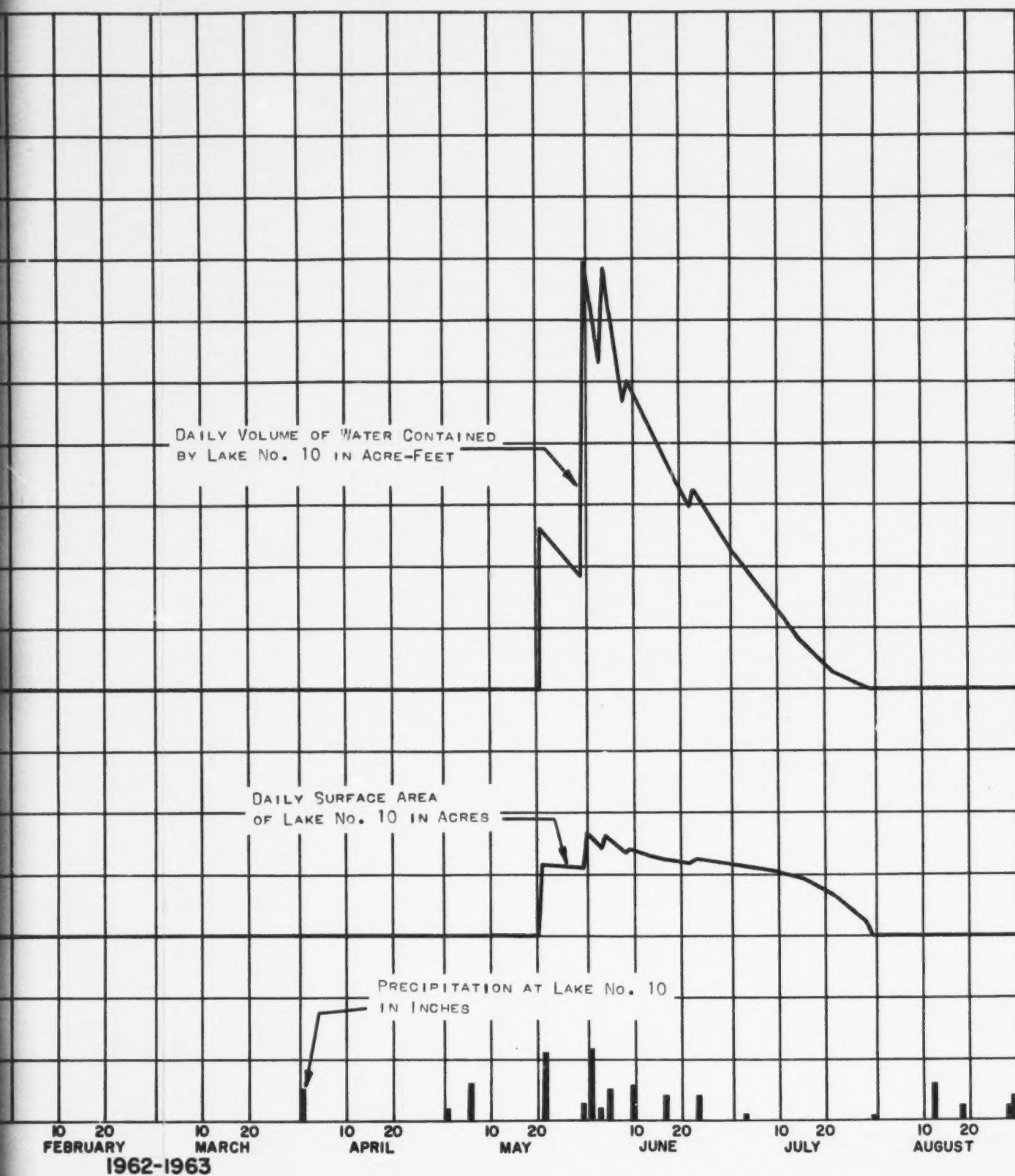


FIGURE 18. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE



LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE NO. 10 (DUPREE).

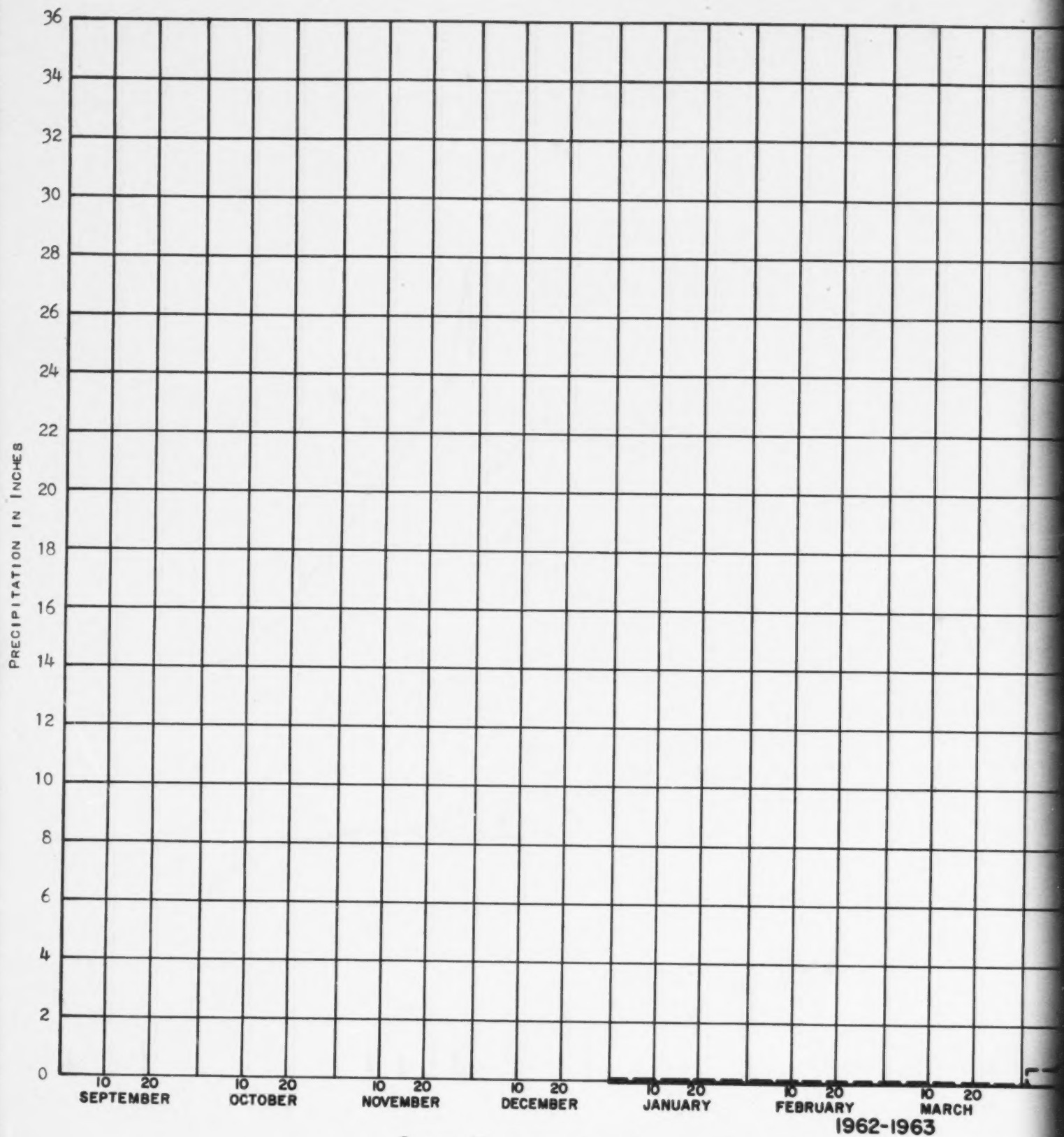
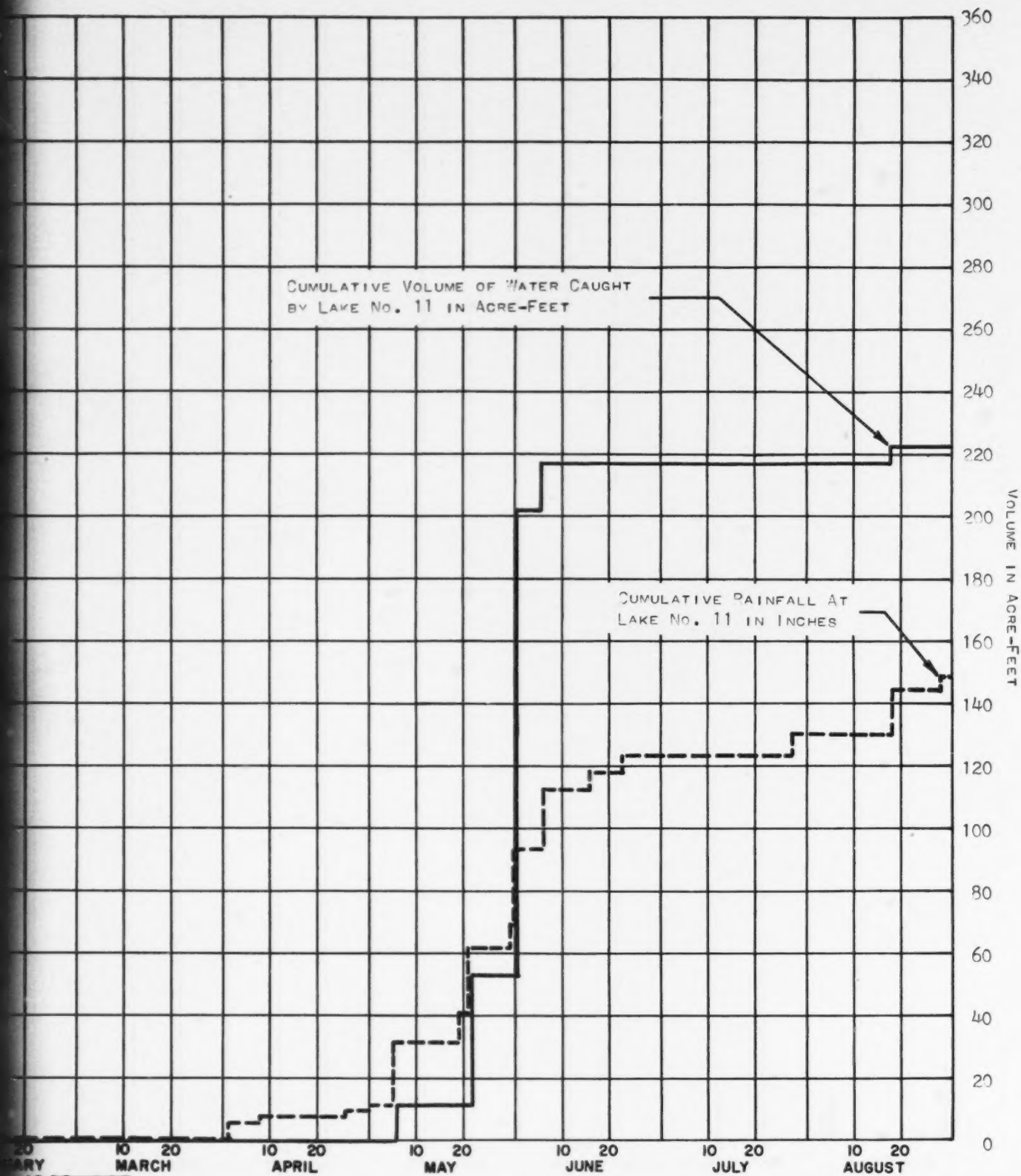


FIGURE 19. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER CAUSE



1962-1963

CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE NO. 11 (KRUEGER).



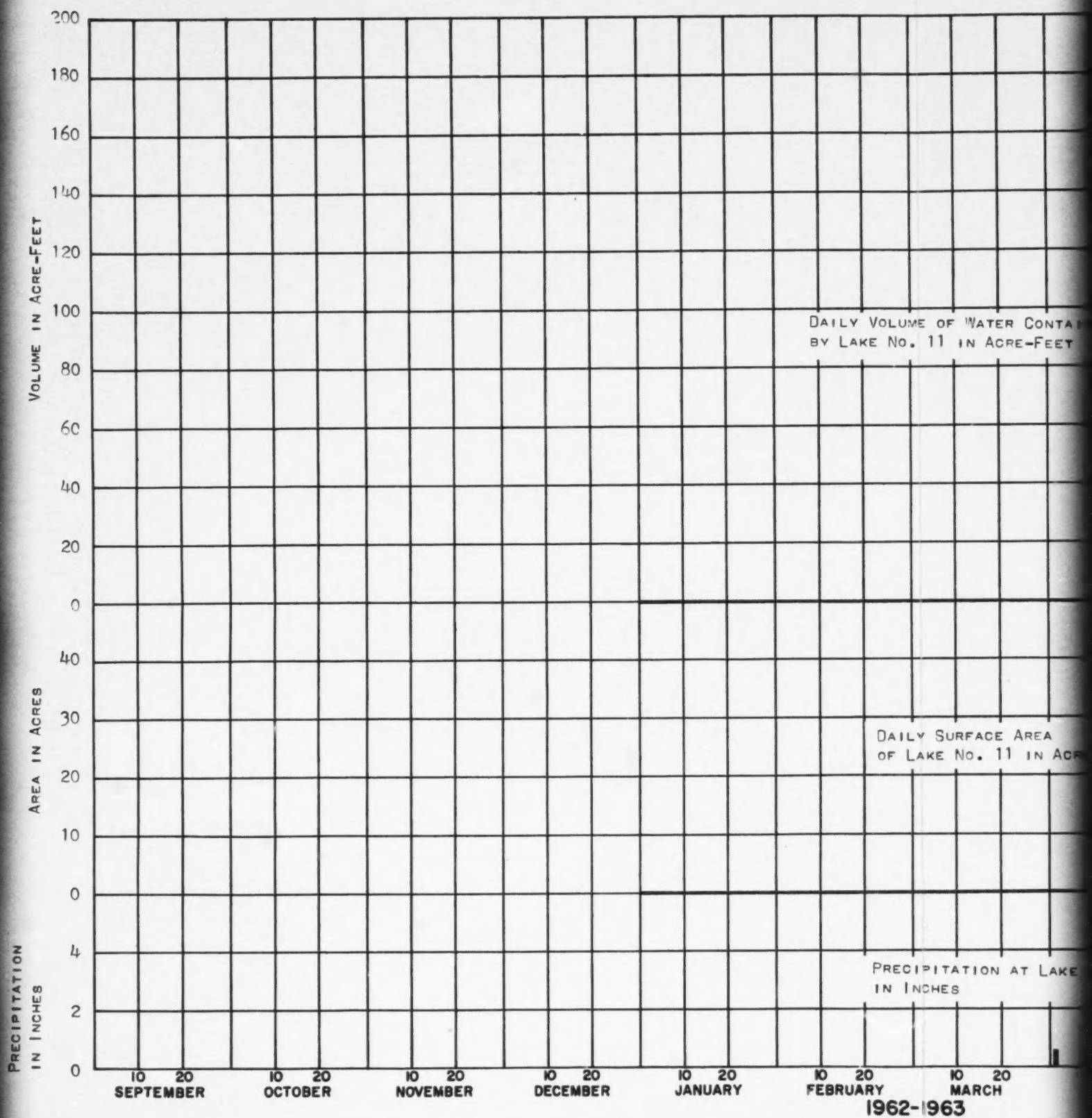
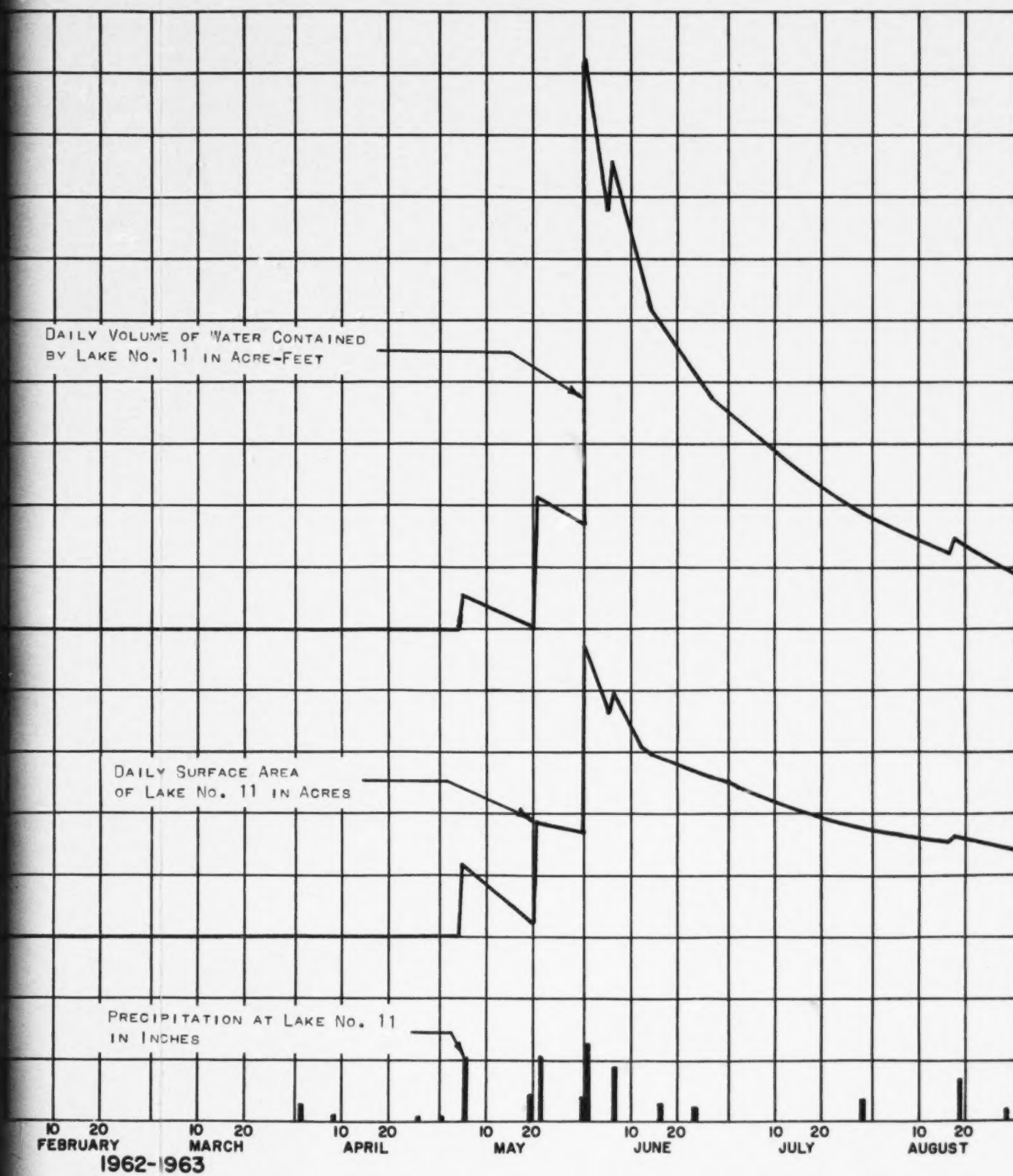


FIGURE 20. DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE



LAKE, DAILY SURFACE AREA OF LAKE AND PRECIPITATION AT LAKE NO. 11 (KRUEGER).

APPENDIX III.  
Mosquito Larvae Production Graphs

Table 1. The total number of larvae dipped during weekly sampling periods on each lake and the percent that was Culex tarsalis. Summers of 1962 and 1963. Lubbock County, Texas.

| Date           | II<br>1962-1963   | III<br>1962-1963 | IV<br>1962-1963 | V<br>1962-1963 | VI<br>1962-1963 | VIII<br>1962-1963 | IX<br>1962-1963 | X<br>1962-1963 |
|----------------|-------------------|------------------|-----------------|----------------|-----------------|-------------------|-----------------|----------------|
| Mar 31-Apr 6   | Total No. dry 3   | dry              | dry             | dry 317        | dry dry         | dry dry           | dry 29          | dry 64         |
| April 7-13     | %Culex tarsalis - | -                | -               | 1237           | -               | -                 | 0               | -              |
| April 14-20    | -                 | -                | -               | 0              | -               | -                 | 217             | dry            |
| April 21-27    | -                 | -                | -               | dry            | -               | -                 | 0               | -              |
| April 28-May 4 | -                 | -                | -               | dry            | -               | dry               | dry             | -              |
| May 5-11       | -                 | -                | -               | dry            | -               | 1                 | -               | -              |
| May 12-18      | -                 | -                | -               | dry            | dry             | -                 | -               | -              |
| May 19-25      | -                 | -                | -               | dry            | dry             | -                 | dry             | dry            |
| May 26-June 1  | 298               | -                | -               | 51             | 1               | 1                 | 4               | 4              |
| June 2-8       | 0                 | -                | -               | 70             | 10              | -                 | -               | 0              |
| June 9-15      | 1                 | -                | -               | 0              | 0               | 0                 | 458             | 0              |
| June 16-22     | -                 | -                | -               | 5              | 0               | 0                 | 73              | 0              |
| June 23-29     | -                 | -                | -               | -              | 0               | dry               | -               | 0              |
| June 30-July 6 | -                 | -                | -               | 0              | 0               | -                 | 42              | 0              |
| July 7-13      | -                 | -                | -               | 0              | 0               | -                 | 100             | 0              |
| July 14-20     | -                 | -                | -               | 1              | 0               | -                 | 29              | 0              |
| July 21-27     | -                 | -                | -               | 100            | 0               | -                 | -               | 0              |
| July 28-Aug 3  | -                 | -                | -               | 6              | 0               | -                 | 2               | 0              |
| Aug 4-10       | -                 | -                | -               | 100            | 0               | -                 | 100             | 0              |
|                | -                 | -                | -               | 23             | 0               | -                 | 39              | 44             |
|                | -                 | -                | -               | 100            | 0               | -                 | -               | 100            |
|                | -                 | -                | -               | 55             | 0               | -                 | 16              | 86             |
|                | -                 | -                | -               | -              | 0               | -                 | 100             | 100            |
|                | -                 | -                | -               | 261            | 0               | -                 | 38              | dry 227        |
|                | 11                | dry              | dry             | -              | dry 3           | -                 | -               | -              |
|                | 100               | 40               | 37              | dry 6          | -               | -                 | 142             | 64 84          |
|                | dry               | -                | -               | 100            | 0               | -                 | 100             | 100            |
|                | 253               | 281              | 697             | 137            | 0               | -                 | 110             | 220            |
|                | 0                 | 100              | 95              | 75             | 0               | -                 | 100             | 11             |
|                | 511               | 173              | 607             | 786            | 0               | -                 | dry             | 126            |
|                | 88                | 100              | 93              | 68             | 0               | -                 | dry             | -              |



Table I. Continued

| Date                                   | II<br>1962-1963 | III<br>1962-1963 | IV<br>1962-1963 | V<br>1962-1963 | VI<br>1962-1963 | VIII<br>1962-1963 | IX<br>1962-1963 | X<br>1962-1963 |
|----------------------------------------|-----------------|------------------|-----------------|----------------|-----------------|-------------------|-----------------|----------------|
| Aug 11-17 Total No.<br>%Culex tarsalis | 29<br>100       | 217<br>100       | 456<br>97       | 814<br>85      | dry<br>0        | dry<br>40         | dry<br>dry      | 134<br>75      |
| Aug 18-24                              | 229<br>100      | 24<br>dry        | 496<br>100      | 194<br>30      | dry             | dry               | dry             | 106            |
| Aug 25-31                              | 79<br>100       | 156<br>dry       | 25<br>dry       | 70<br>0        | dry             | 0<br>dry          | dry             | dry            |
| Sept 1-7                               | 7<br>0          | 83<br>100        | 340<br>dry      | 178<br>7       | 14<br>dry       | 0<br>dry          | 177<br>dry      | 831            |
| Sept 8-14                              | 268<br>0        | 77<br>dry        | dry             | 235<br>45      | 68<br>dry       | 42<br>0           | 100<br>dry      | 29             |
| Sept 15-21                             | 127<br>100      | 8<br>dry         | 24<br>dry       | 0<br>94        | 1<br>dry        | 0<br>0            | 215<br>dry      | 85             |
| Sept 22-28                             | 574<br>100      | dry              | dry             | 0<br>80        | 0<br>dry        | 33<br>0           | 100<br>dry      | 46             |
| Sept 29-Oct 5                          | 100<br>124      | 2<br>dry         | 20<br>dry       | dry            | dry             | 17<br>0           | 31<br>dry       | 10             |
| Oct 6-12                               | 100<br>203      | dry              | 16<br>30        | dry            | dry             | 28<br>0           | 33<br>dry       | 258            |
| Oct 13-19                              | 89<br>dry       | dry              | 0<br>dry        | 2<br>dry       | dry             | 34<br>0           | dry             | dry            |
| Oct 20-26                              | 19<br>dry       | dry              | 0<br>dry        | 159<br>dry     | dry             | 71<br>0           | dry             | 39             |
| Oct 27-Nov 2                           | dry             | dry              | 2<br>dry        | 661<br>dry     | dry             | 86<br>0           | dry             | 286            |
| Nov 3-9                                | 109<br>dry      | dry              | 6<br>dry        | 437<br>dry     | dry             | 60<br>0           | dry             | dry            |
| Nov 10-16                              | dry             | dry              | 87<br>dry       | dry            | dry             | 56<br>0           | dry             | dry            |
| Nov 17-23                              | dry             | dry              | 15<br>dry       | dry            | dry             | 61<br>0           | dry             | dry            |
| Nov 24-30                              | dry             | dry              | 6<br>dry        | dry            | dry             | 16<br>0           | dry             | dry            |
| Dec 1-7                                | dry             | dry              | 0<br>dry        | dry            | dry             | 26<br>dry         | dry             | dry            |
| Dec 8-14                               | dry             | dry              | 0<br>dry        | dry            | dry             | 25<br>dry         | dry             | dry            |
| Dec 15-21                              | dry             | dry              | 0<br>dry        | dry            | dry             | 4<br>dry          | dry             | dry            |
| Dec 22-28                              | dry             | dry              | 0<br>dry        | dry            | dry             | 6<br>dry          | dry             | dry            |
| Dec 29-31                              | dry             | dry              | dry             | dry            | dry             | dry               | dry             | dry            |

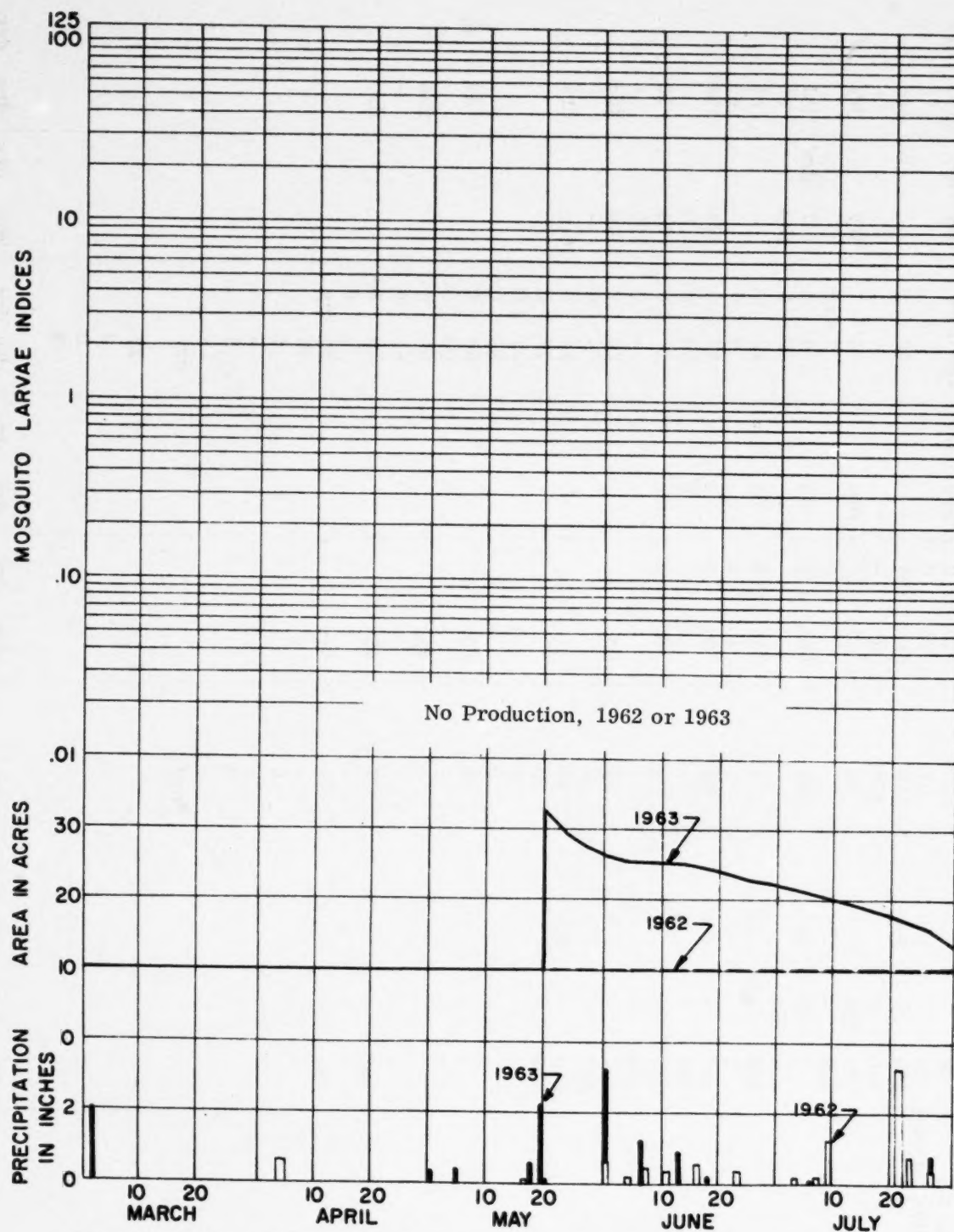


Figure 1A. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Spring and summer 1962 and 1963. Lake I (Huckabee).

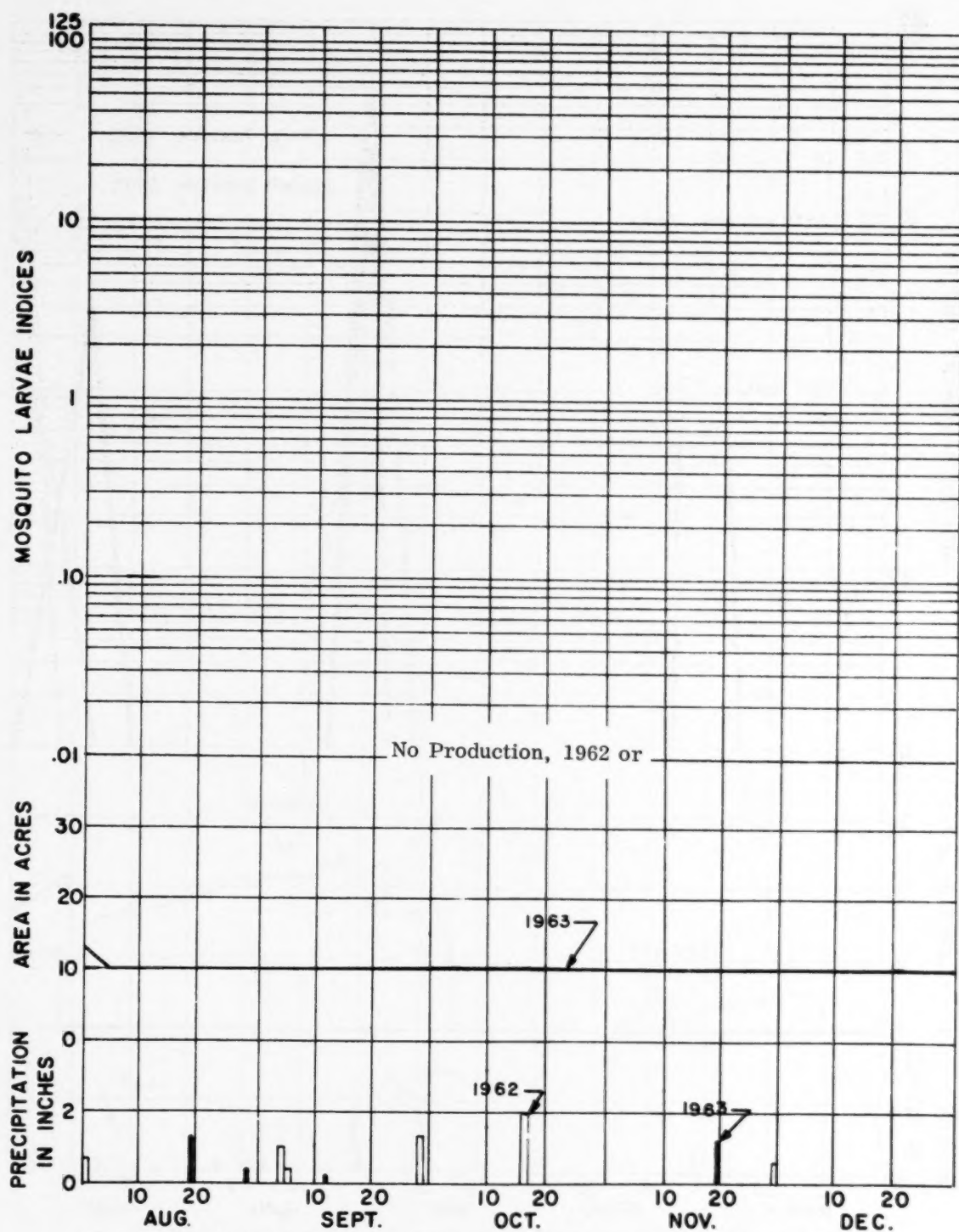


Figure 1B. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1962 and 1963. Lake I (Huckabee).

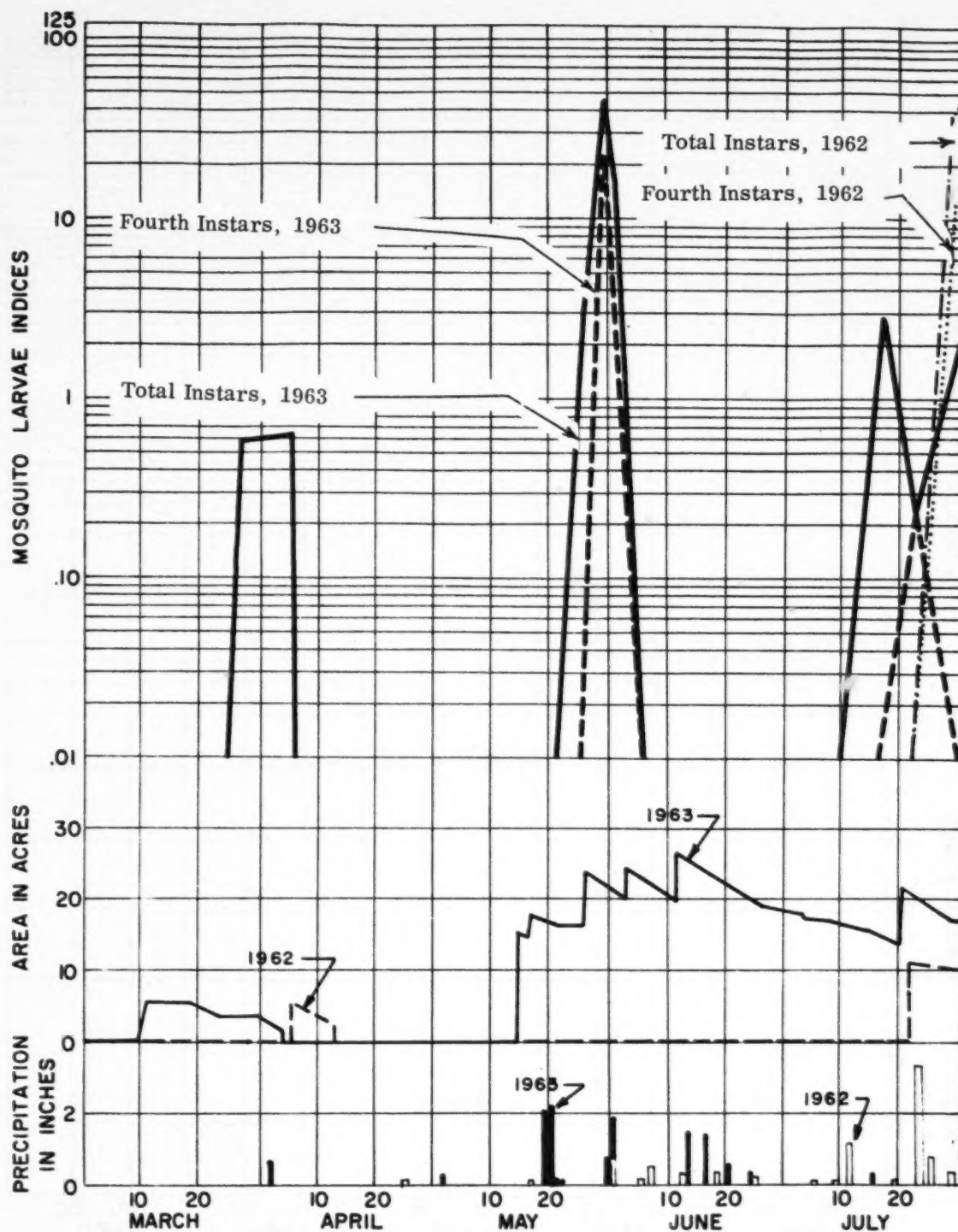


Figure 2A. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Spring and summer 1962 and 1963. Lake II (Knowles).



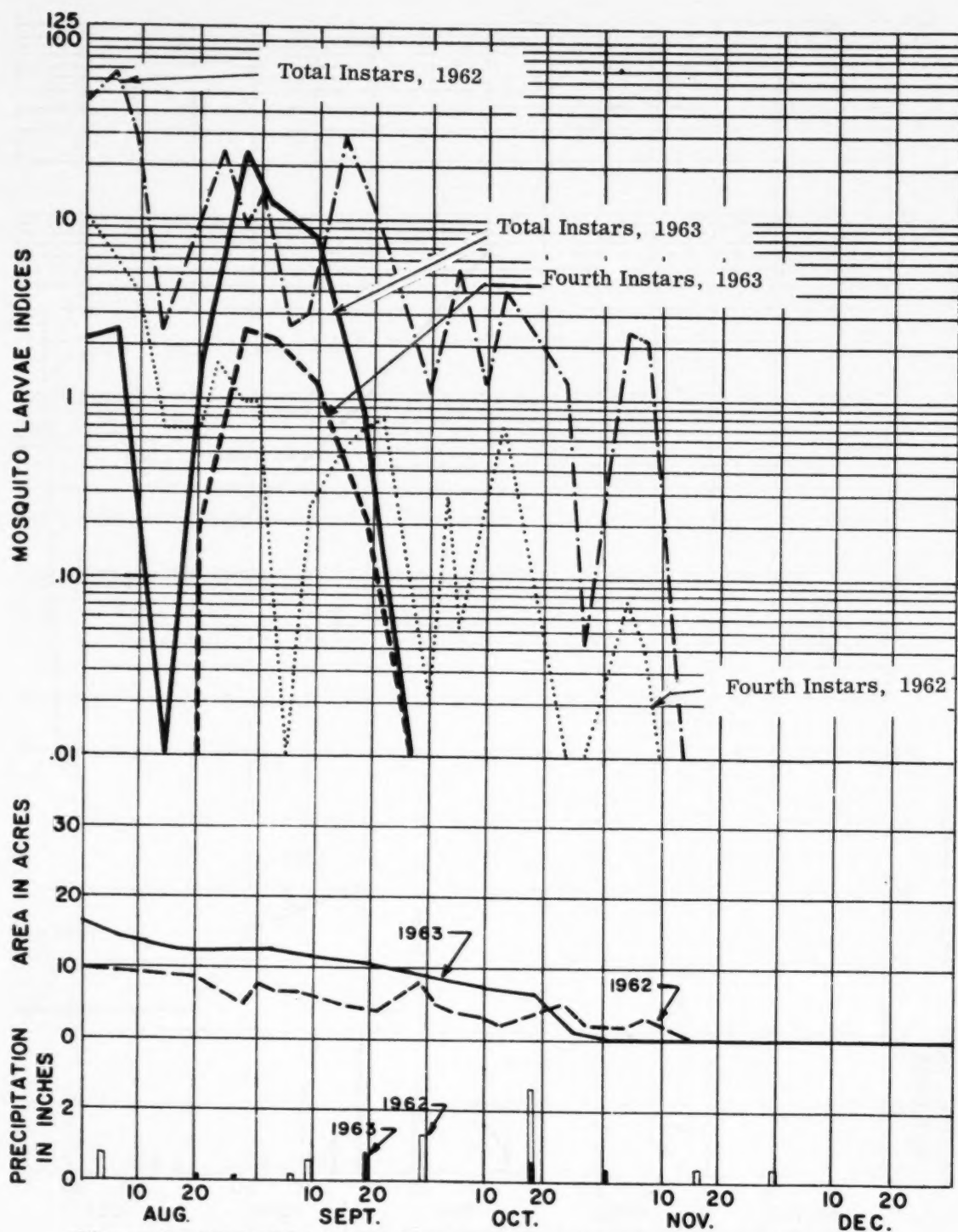


Figure 2B. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1962 and 1963. Lake II (Knowles).

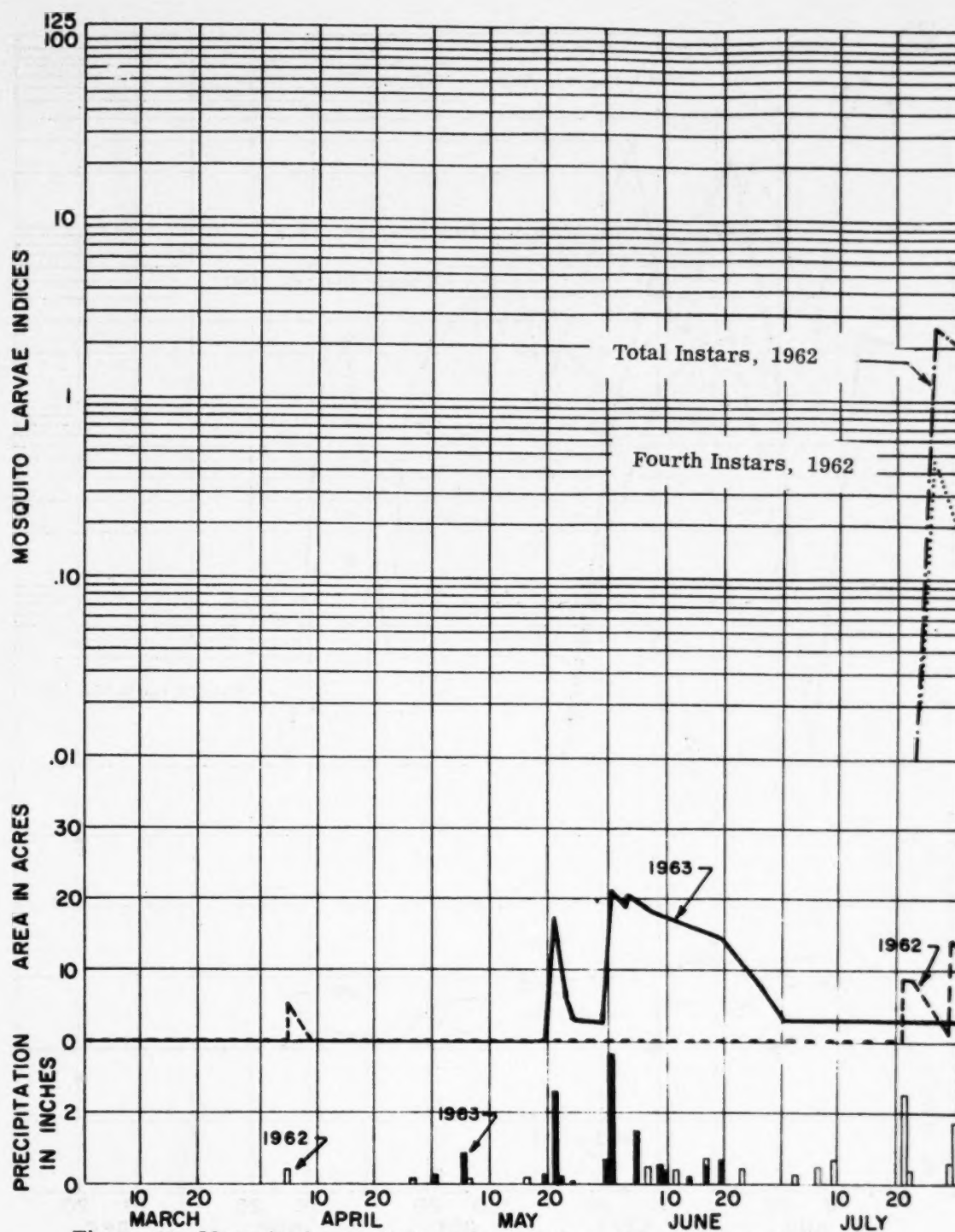


Figure 3A. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Spring and summer 1962 and 1963. Lake III (Hufstedler).

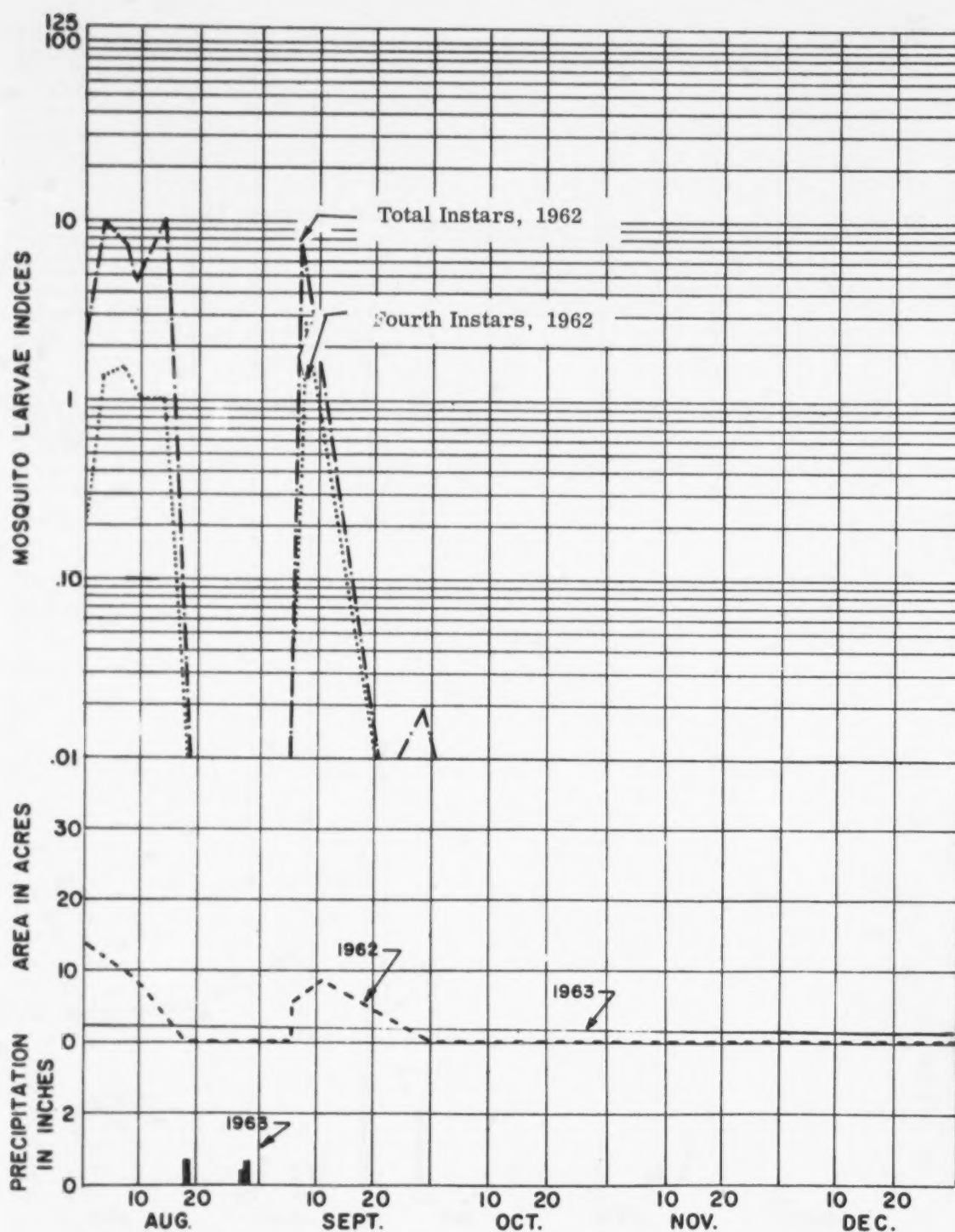


Figure 3B. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1962 and 1963. Lake III (Hufstedler).

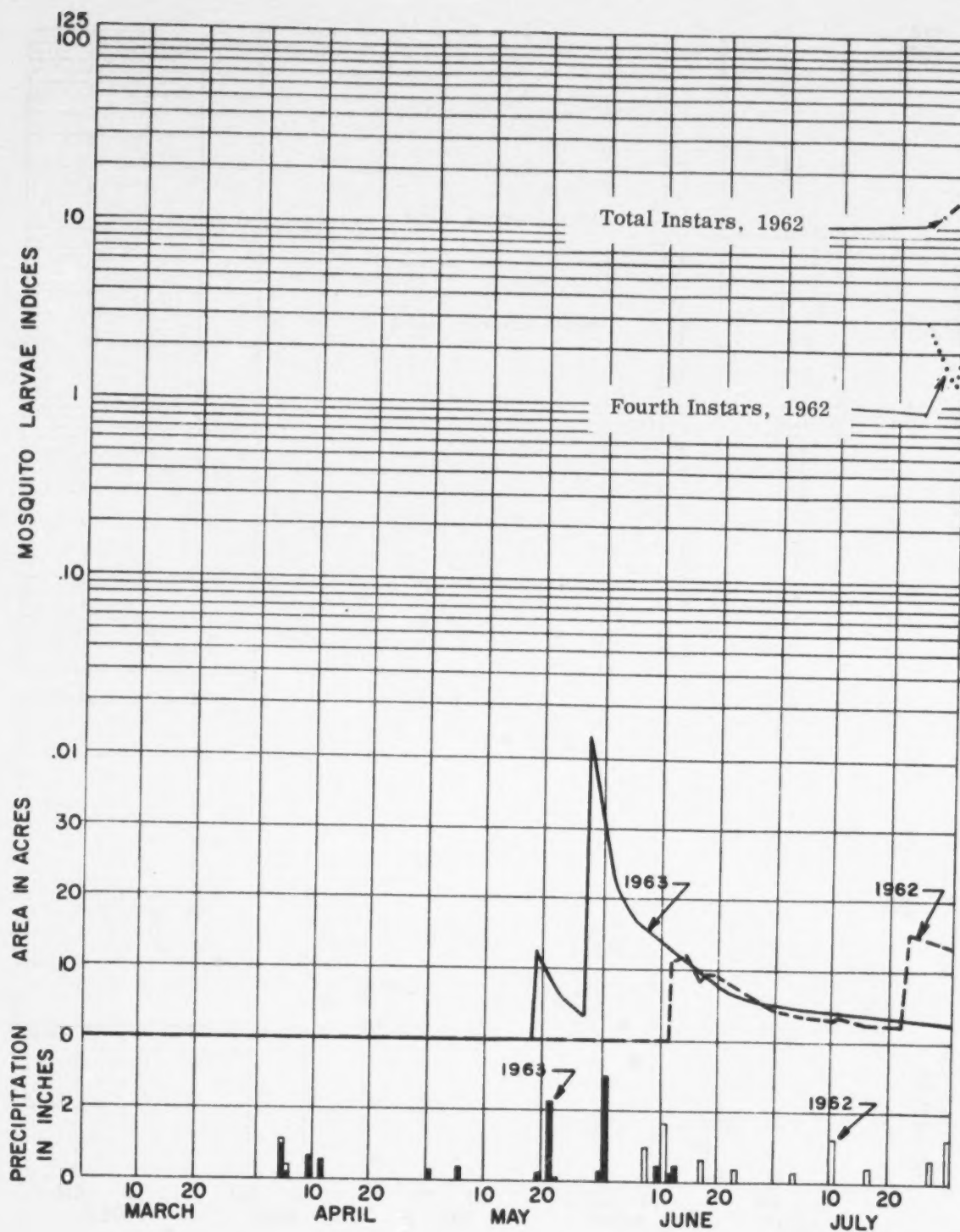


Figure 4A. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Spring and summer 1962 and 1963. Lake IV (L. C. C.).



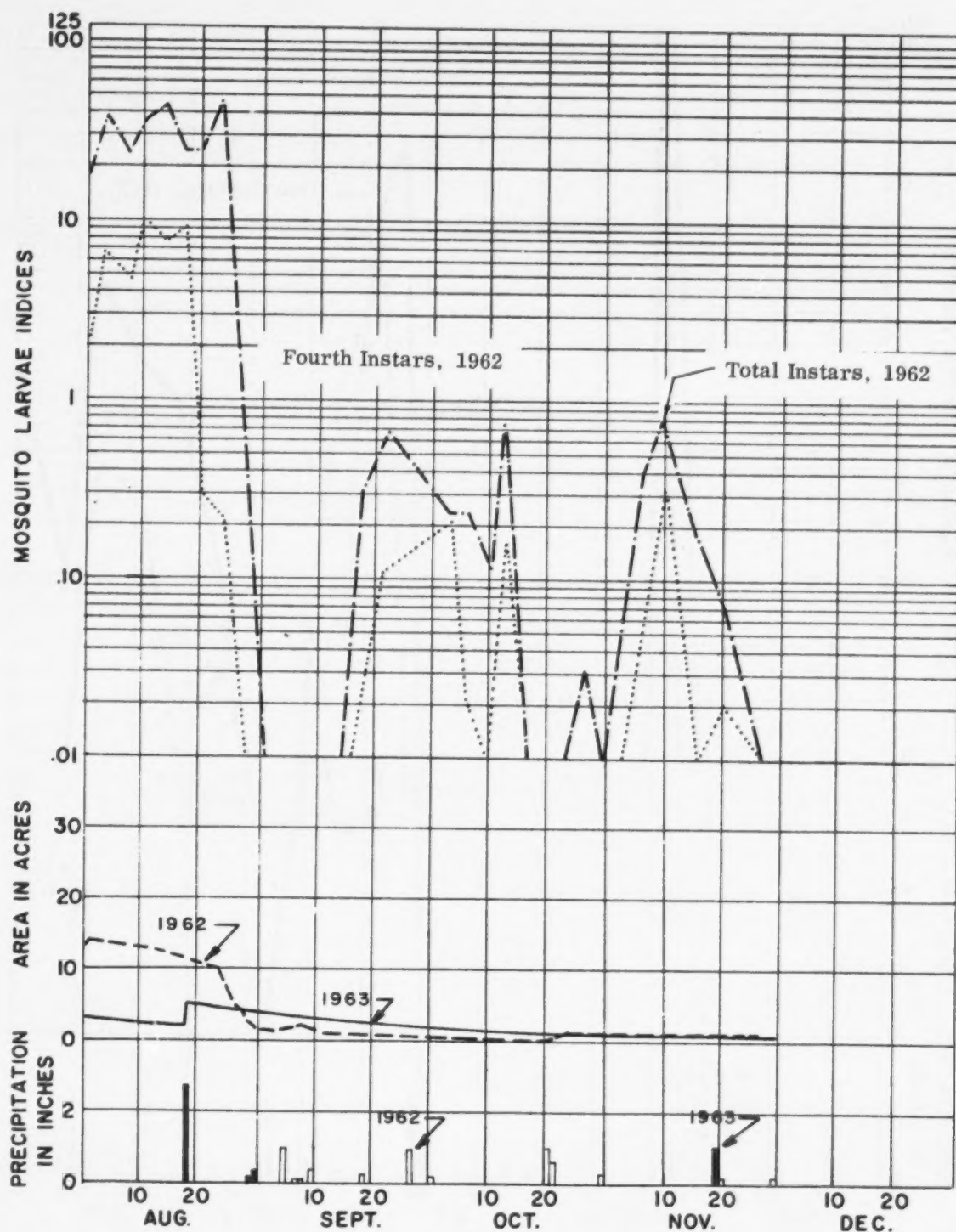


Figure 4B. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1962 and 1963. Lake IV (L. C. C.).

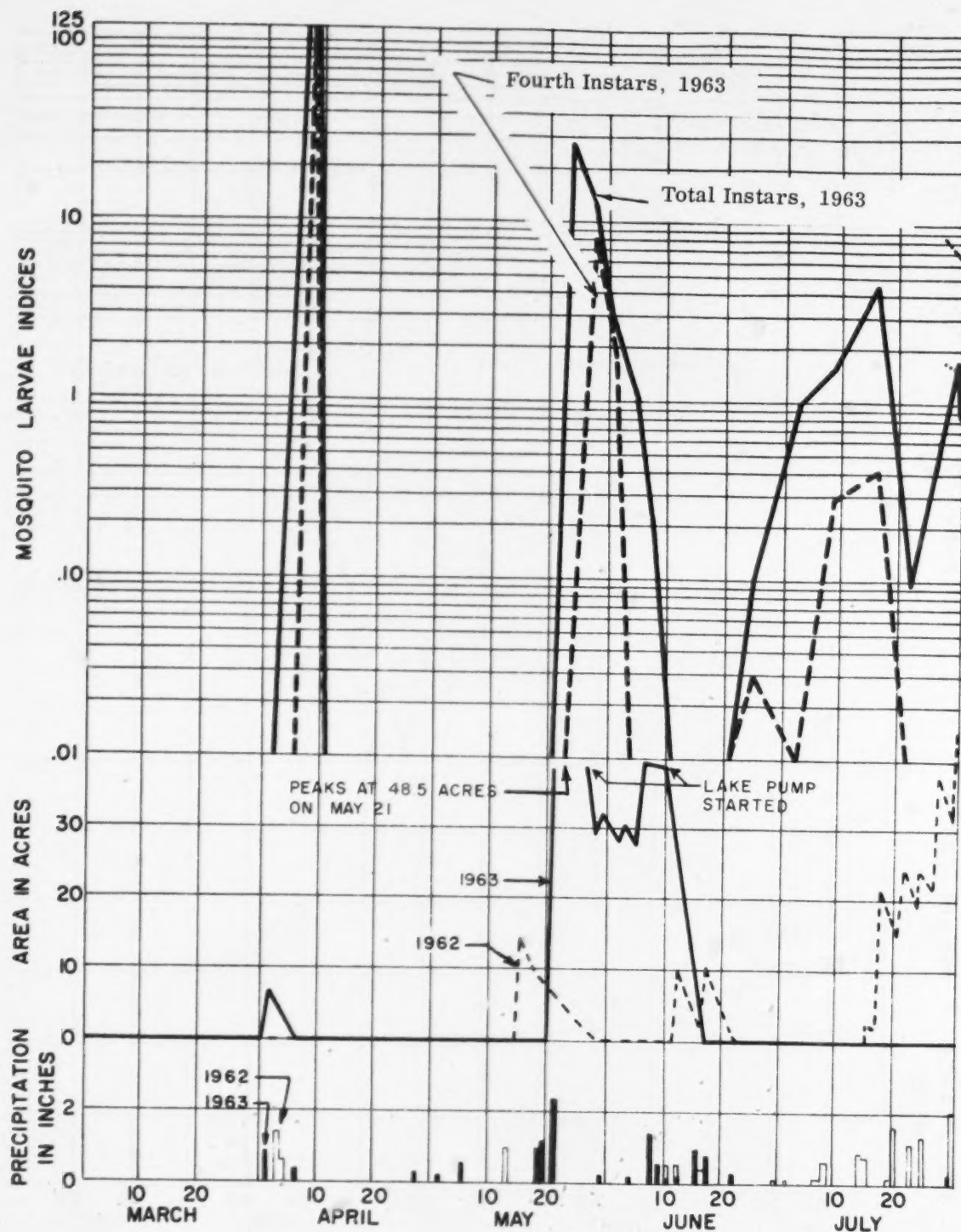


Figure 5A. Mosquito Larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Spring and summer 1962 and 1963. Lake V (Kitten).

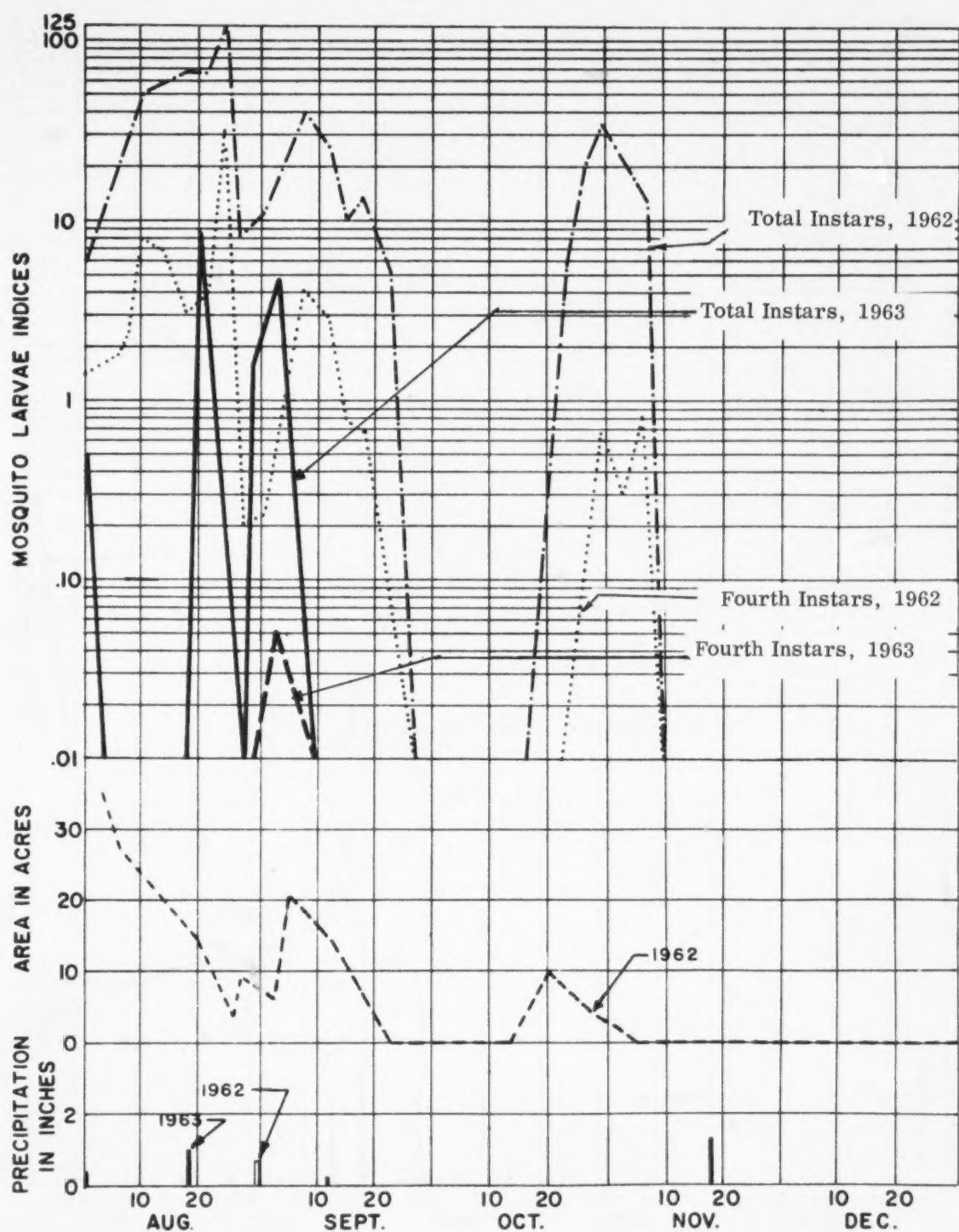


Figure 5B. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1962 and 1963. Lake V (Kitten).

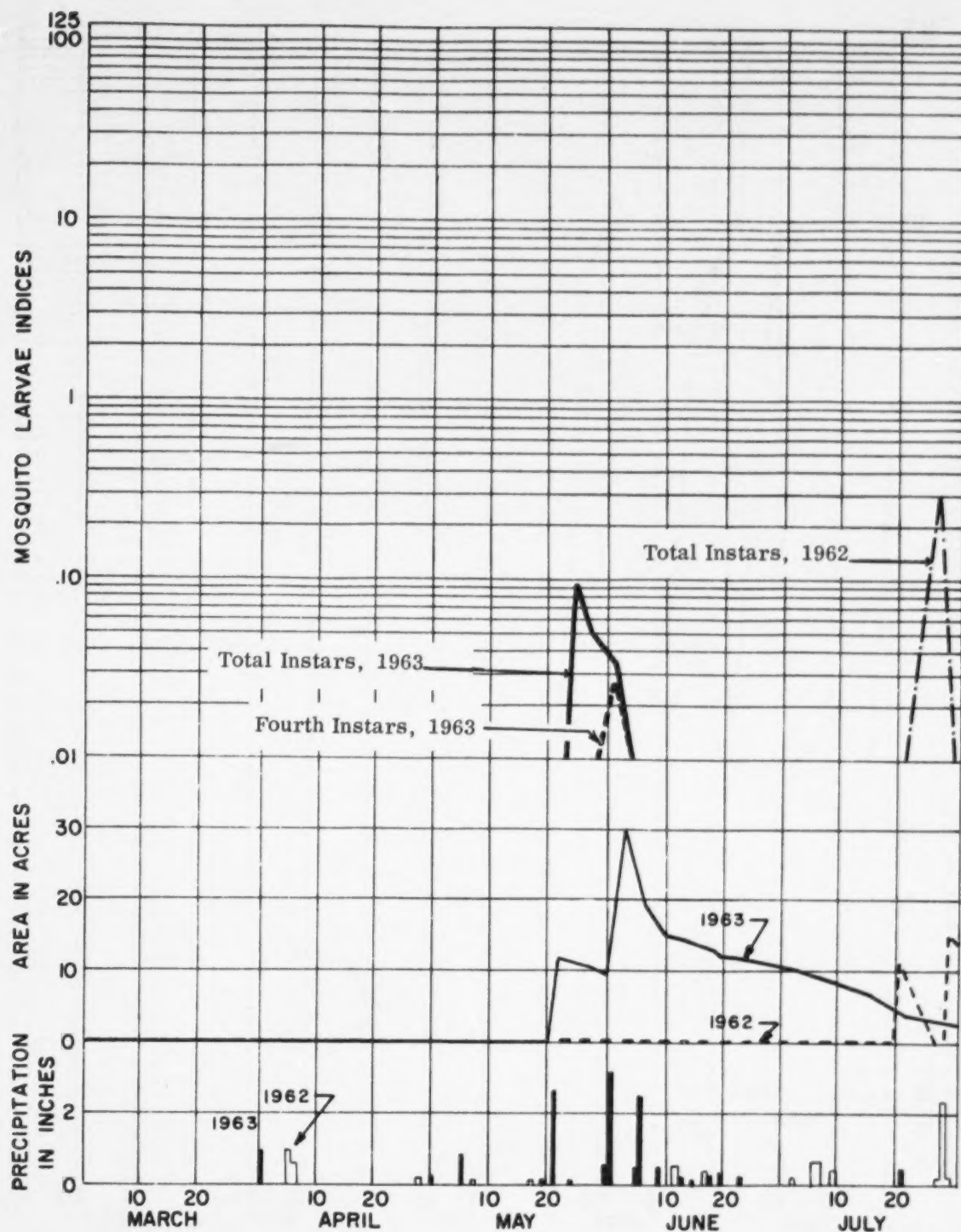


Figure 6A. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Spring and summer 1962 and 1963. Lake VI (Holland).



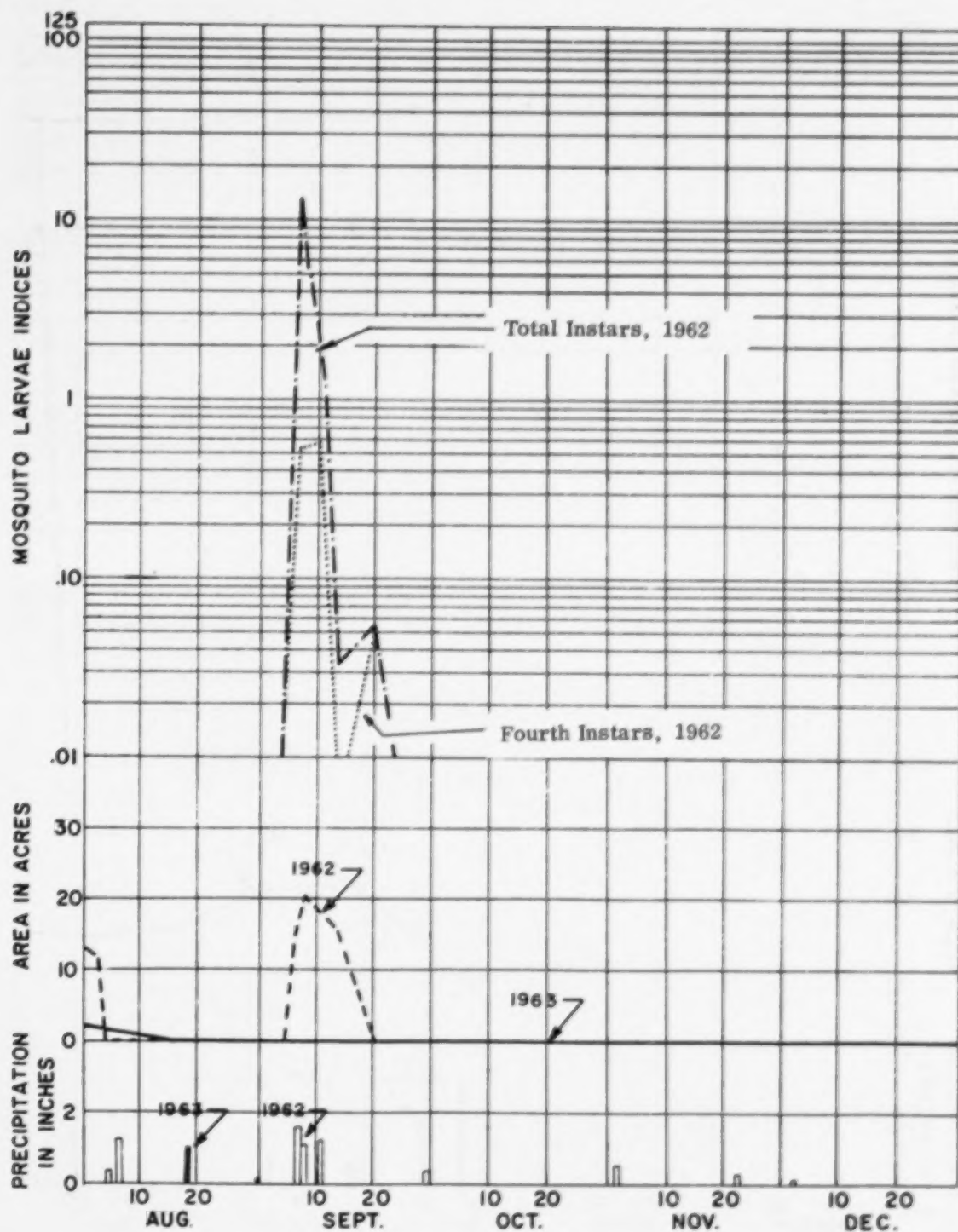


Figure 6B. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1962 and 1963. Lake Vi (Holland).

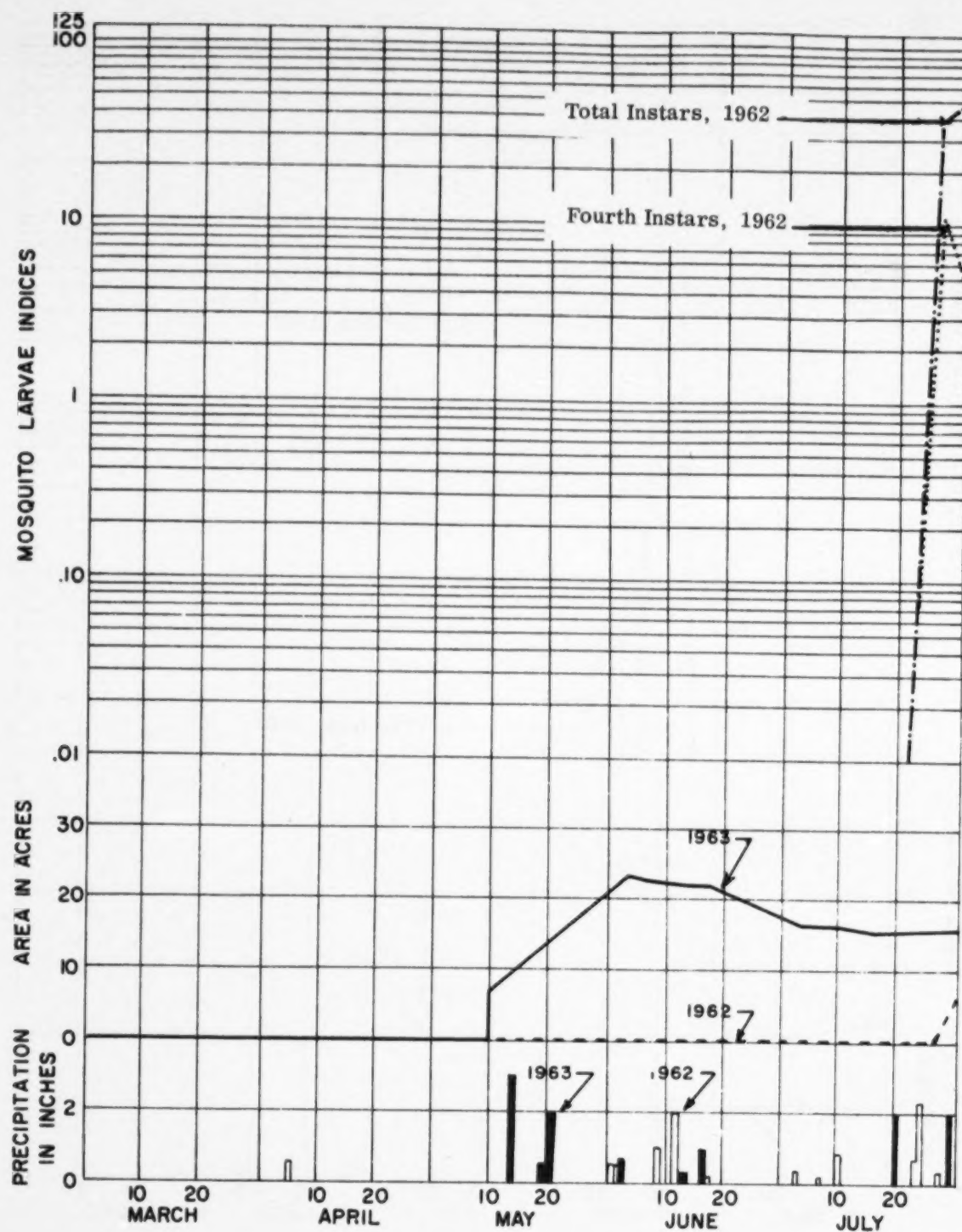


Figure 8A. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Spring and summer 1962 and 1963. Lake VIII (Burgett).

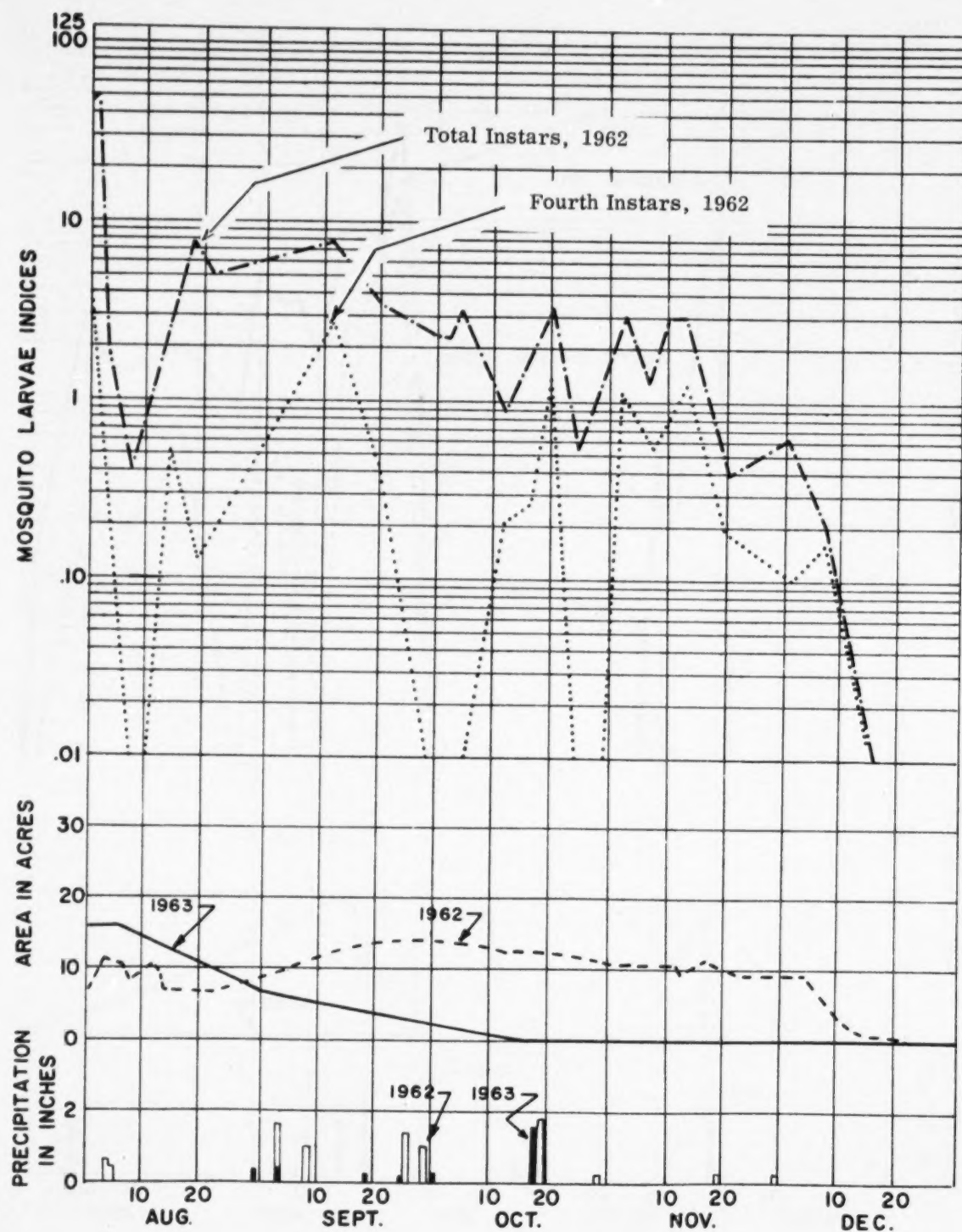


Figure 8B. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1962 and 1963. Lake VIII (Burgett).

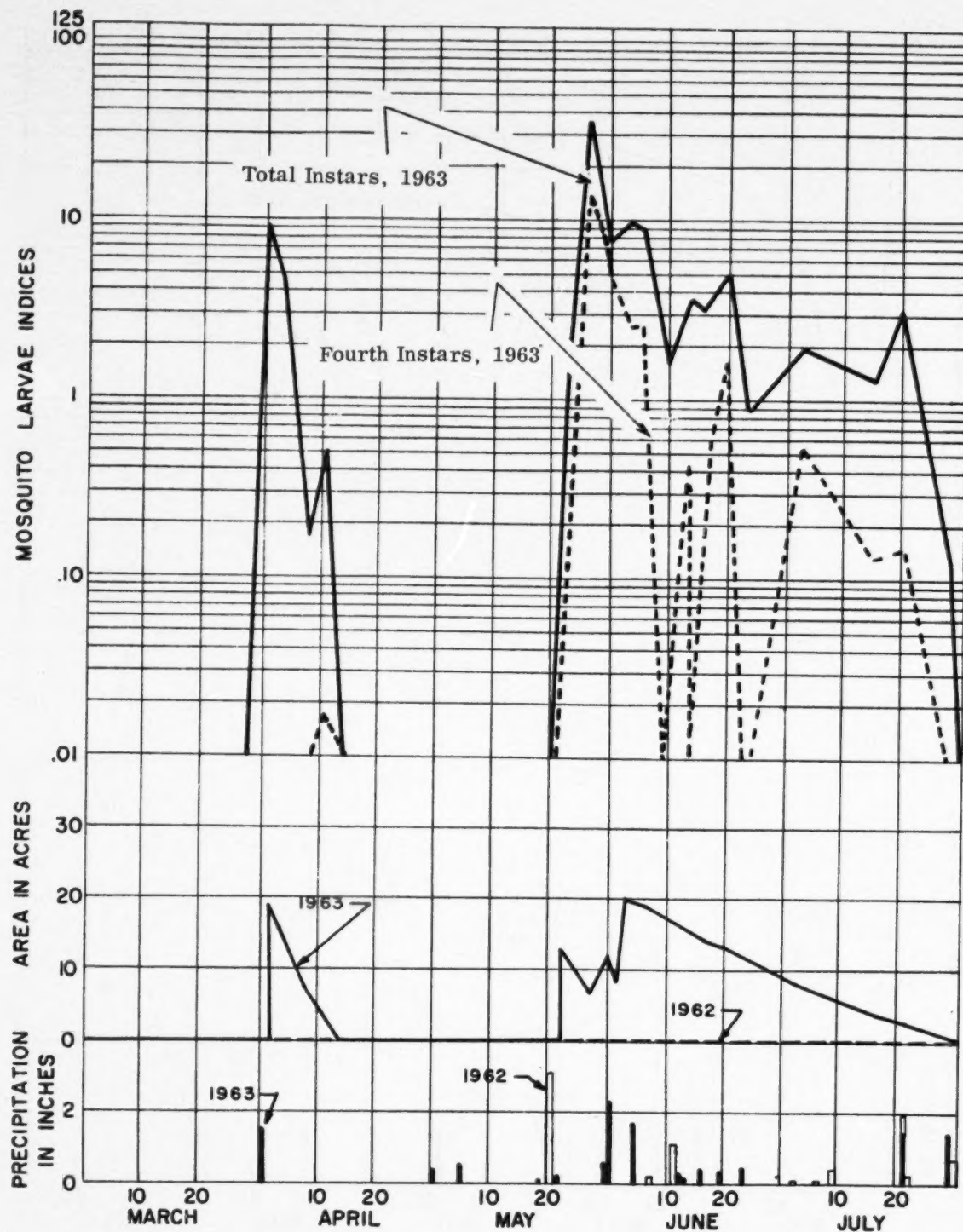


Figure 9A. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals ten transects; in relation to daily surface acres and rainfall. Spring and summer 1962 and 1963. Lake IX (Cox).



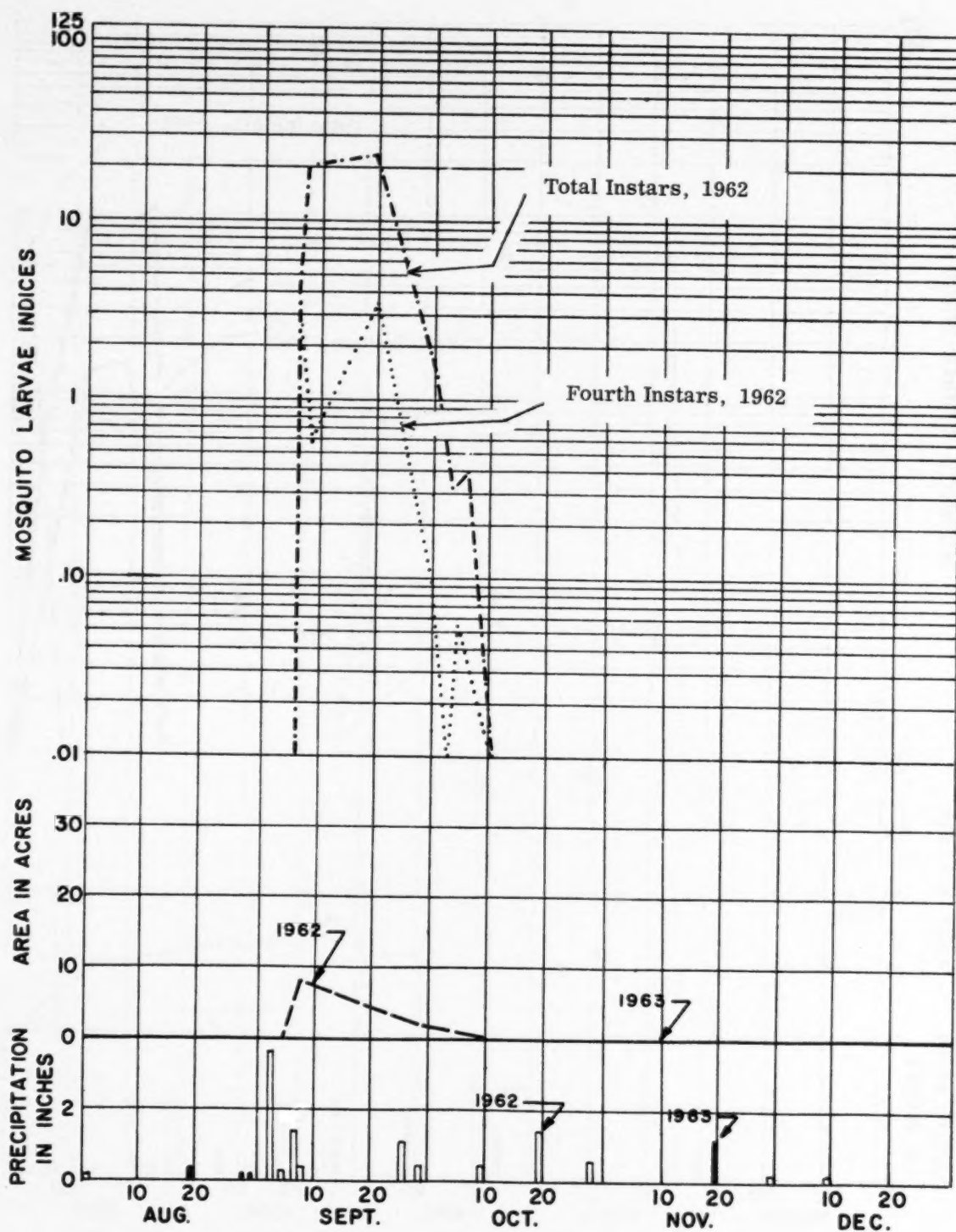


Figure 9B. Mosquito Larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1962 and 1963. Lake IX (Cox).

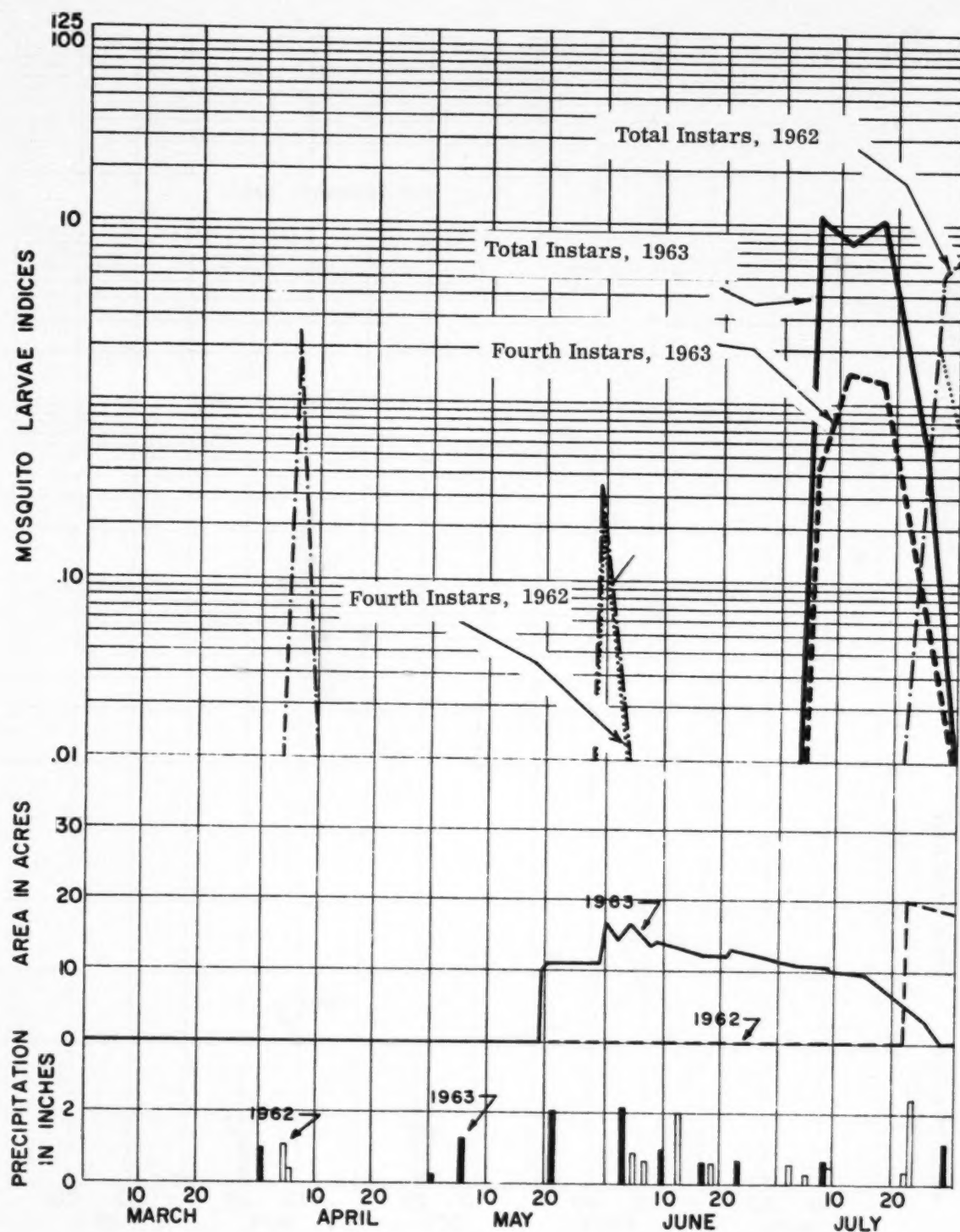


Figure 10A. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Spring and summer 1962 and 1963. Lake X (Reese).

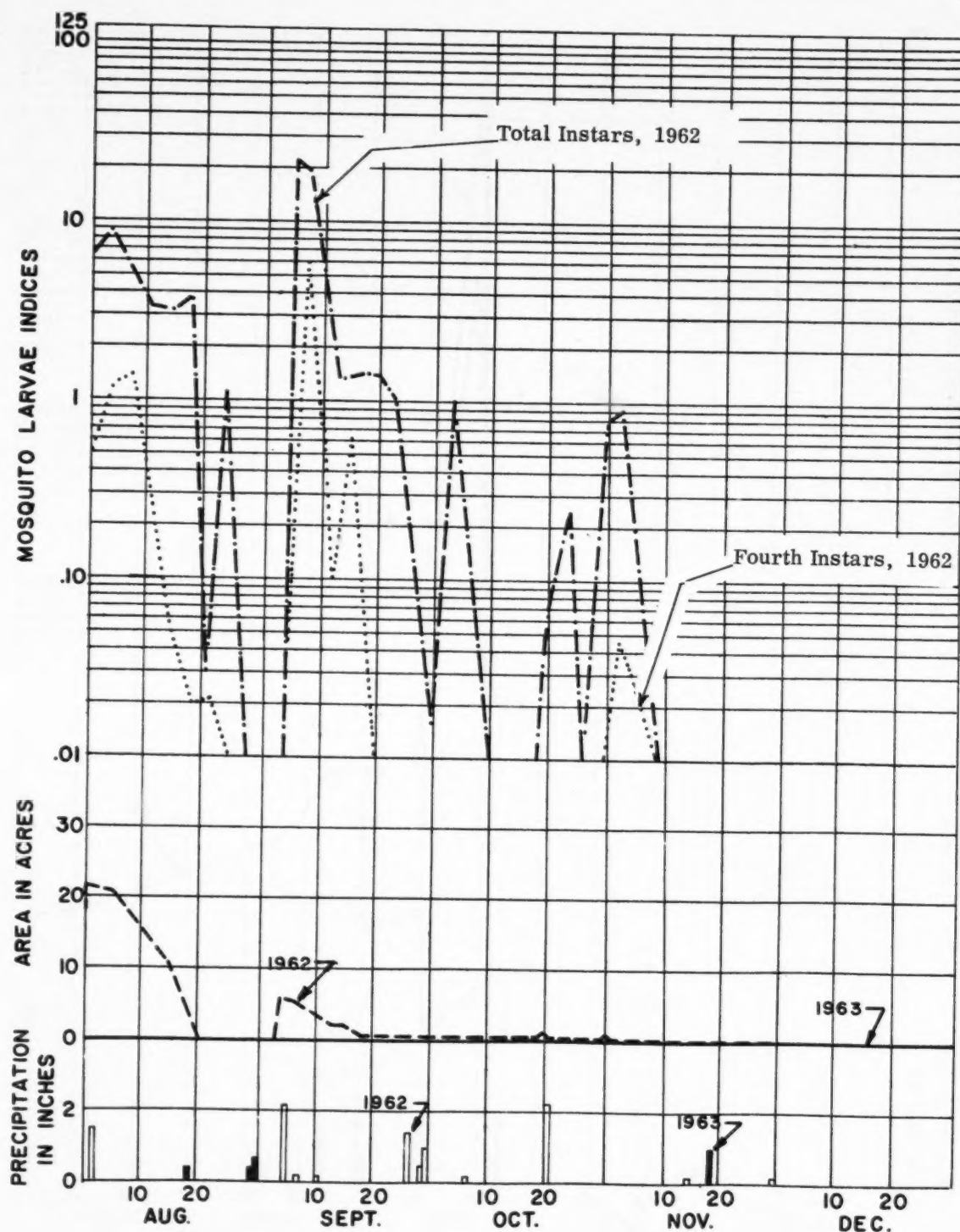


Figure 10B. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken twice weekly during the 1962 season and once weekly during the 1963 season by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1962 and 1963. Lake X (Reese).

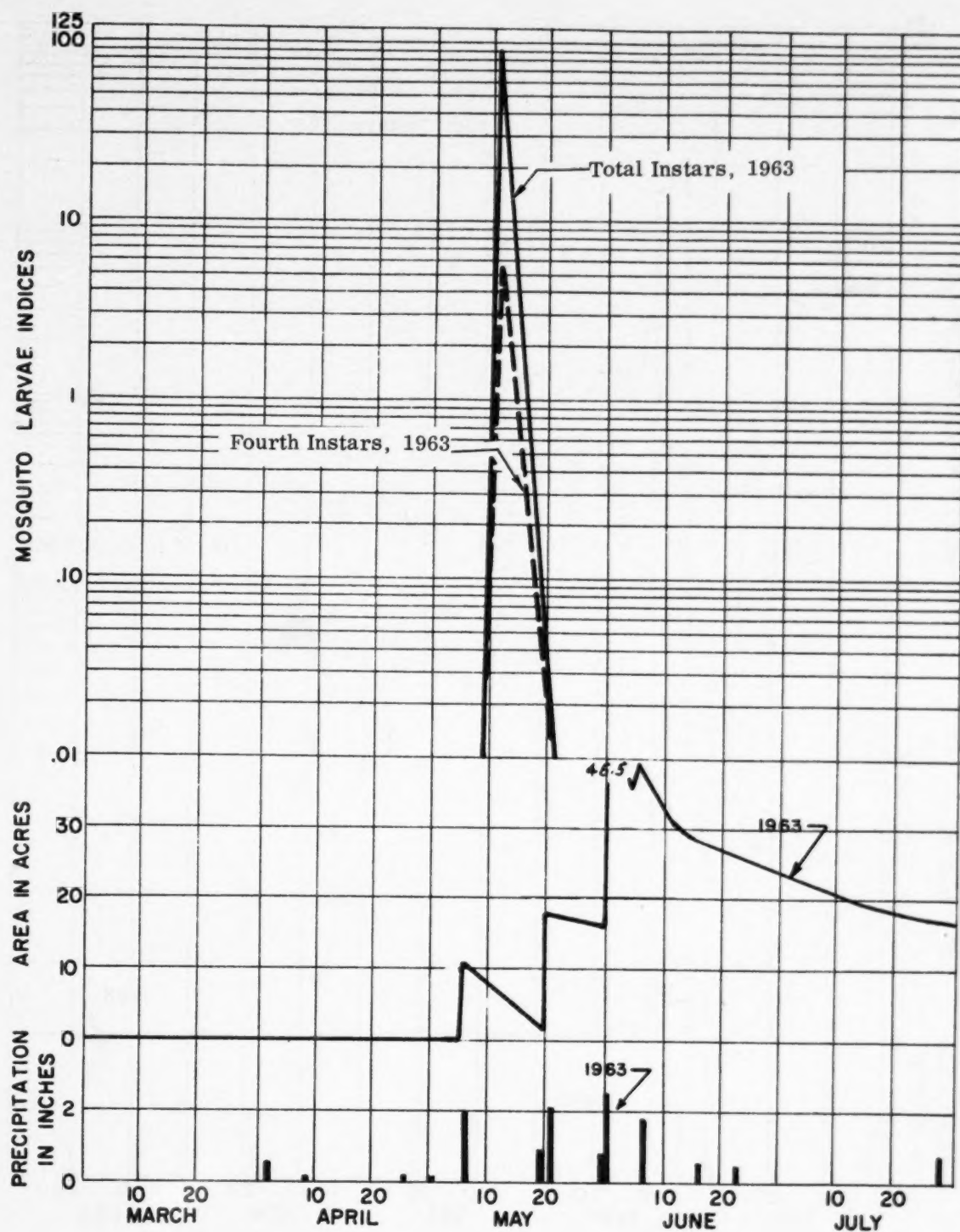


Figure 11A. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken once weekly by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Spring and summer 1963. Lake XI (Krueger).



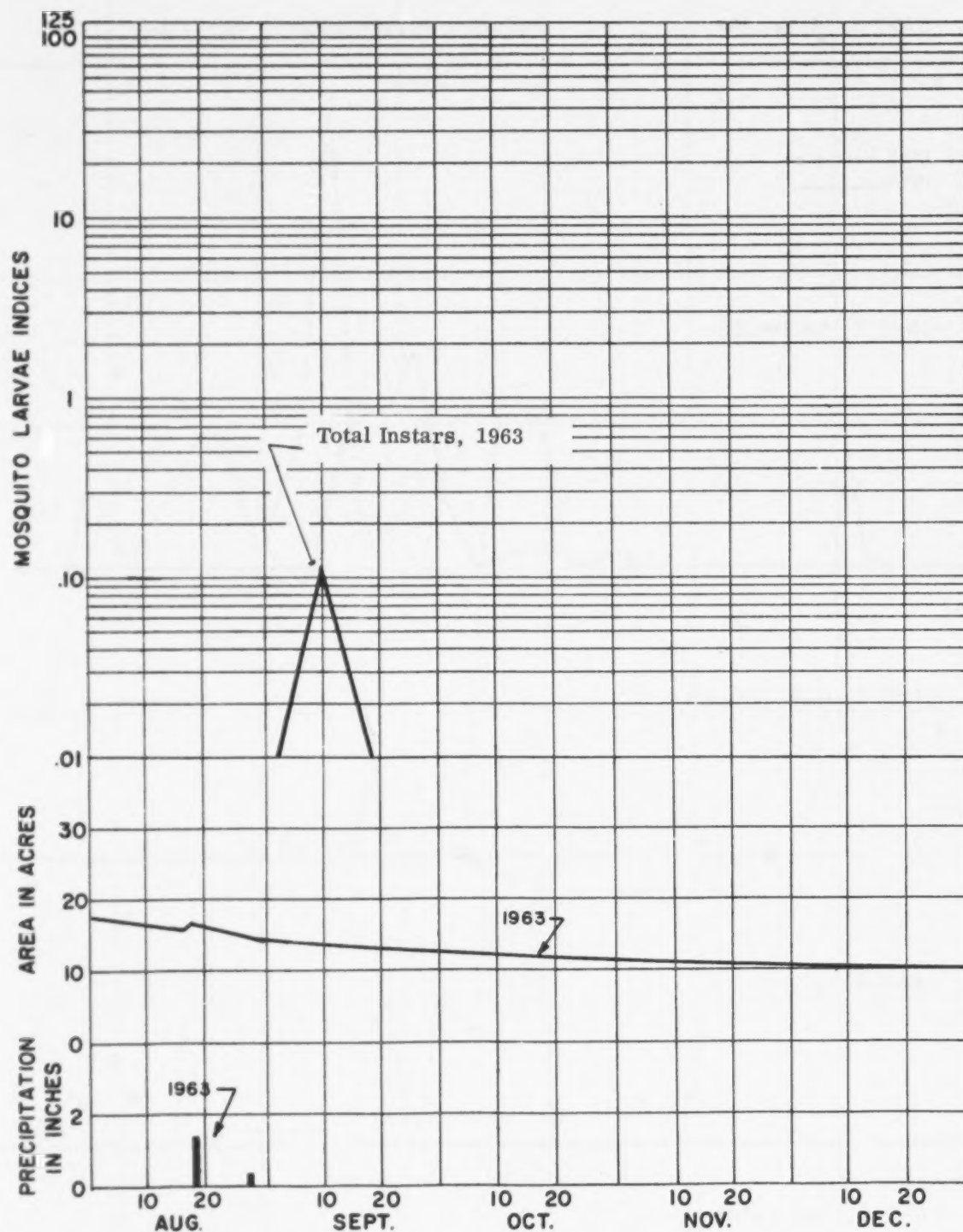


Figure 11B. Mosquito larvae indices presented semi-logarithmically for both fourth instar larvae and total of all instars taken once weekly by sampling at thirty foot intervals on ten transects; in relation to daily surface acres and rainfall. Fall and winter 1963. Lake XI (Krueger).

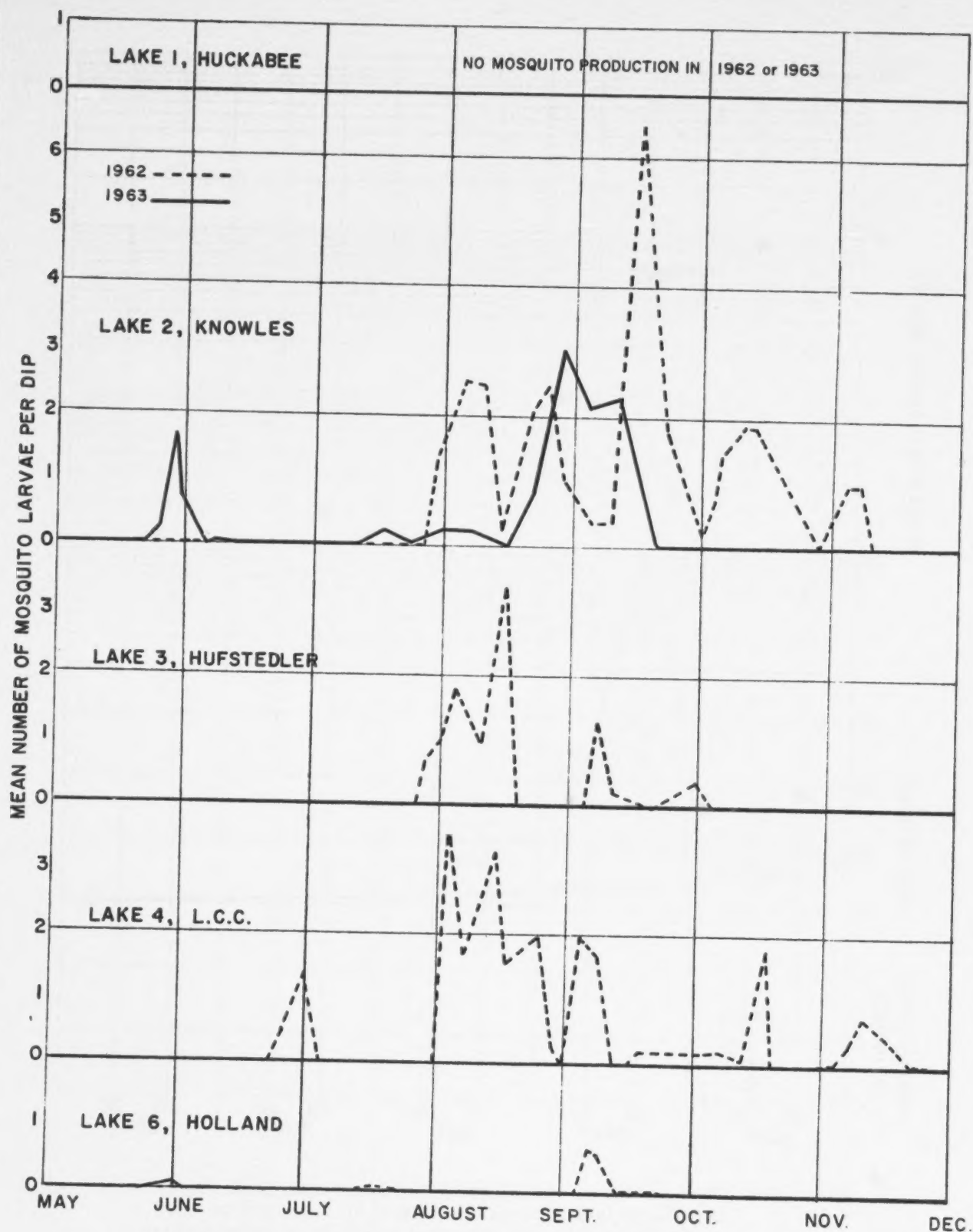


Figure 12A. Mean numbers of mosquito larvae per dip taken once or twice weekly by sampling at thirty foot intervals on ten transects on each lake presented for both the 1962 and 1963 seasons. Lubbock County, Texas.

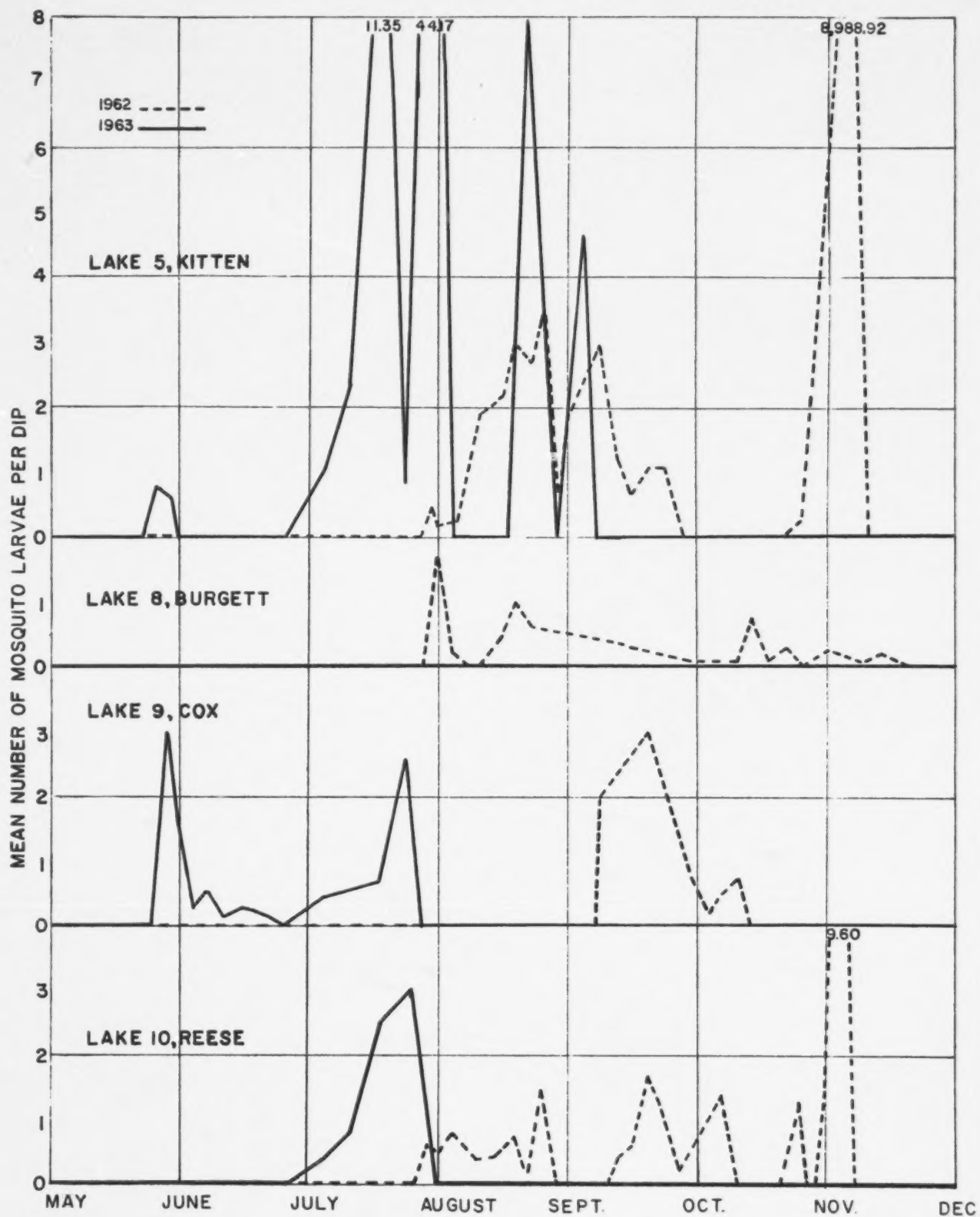


Figure 12B. Mean numbers of mosquito larvae per dip taken once or twice weekly by sampling at thirty foot intervals on ten transects on each lake presented for both the 1962 and 1963 seasons. Lubbock County, Texas.

APPENDIX IV.  
Water Chemistry Data



| DATE    | DISSOLVED OXYGEN |        |            |         |             |             | FREE CO <sub>2</sub> | ALKALINITY | pH   |
|---------|------------------|--------|------------|---------|-------------|-------------|----------------------|------------|------|
|         | ZONE             | P.P.M. | WATER TEMP | TIME    | WATER DEPTH | TOTAL COVER |                      |            |      |
| JUNE 18 | OW               | 7.15   | 71°F       | 9:45AM  | 28"         | 0%          | 0.00                 | 43.62      | 8.35 |
|         | WZ               | 7.90   | 73°F       | 10:10AM | 5"          | 40%         | 0.00                 | 46.06      | 8.60 |
|         | SL               | 7.15   | 75°F       | 9:30AM  | 1/2"        | 0%          | 0.00                 | 46.66      | 8.70 |
| JULY 21 | OW               | 7.40   | 85°F       | 3:35AM  | 28"         | 0%          | 0.00                 | 56.70      | 8.50 |
|         | SL               | 6.50   | 90°F       | 3:20PM  | 1"          | 1%          | 0.00                 | 61.30      | 8.10 |
| AUG. 28 | OW               | 6.60   | 75°F       | 8:57AM  | 20"         | 0%          | 0.00                 | 39.70      | 8.30 |
|         | WZ               | 7.20   | 74°F       | 8:35AM  | 6"          | 45%         | 0.00                 | 42.10      | 8.15 |
|         | SL               | 7.38   | 74°F       | 8:00AM  | 1/2"        | 15%         | 0.00                 | 42.70      | 7.78 |
| OCT. 9  | OW               | 8.20   | 69°F       | 12:30PM | 18"         | 0%          | 0.00                 | 48.19      | 8.93 |
|         | SL               | 10.10  | 71°F       | 12:15PM | 1/2"        | 0%          | 0.00                 | 50.33      | 8.63 |
| DEC. 12 | OW               | 10.85  | 40°F       | 4:05PM  | 30"         | 0%          | 0.00                 | 57.46      | 8.15 |
|         | SL               | 11.00  | 39°F       | 3:35PM  | 1/2"        | 0%          | 0.00                 | 57.64      | 8.45 |

TABLE 1. AVERAGES OF DUPLICATE ANALYSES RUN EACH SAMPLING DATE FOR DISSOLVED OXYGEN, FREE CARBON DIOXIDE, ALKALINITY AND pH. THE SAMPLES WERE TAKEN ONE-HALF TO TWO INCHES BELOW THE WATER SURFACE IN OPEN WATER (OW), ZONE OF WEED GROWTH (WZ), AND ALONG THE SHORE LINE (SL). LUBBOCK COUNTY, TEXAS. SUMMER, FALL, WINTER 1963. LAKE IV.

| DATE    | DISSOLVED OXYGEN |        |             |         |             |             | FREE CO <sub>2</sub> | ALKA-LINITY | pH   |
|---------|------------------|--------|-------------|---------|-------------|-------------|----------------------|-------------|------|
|         | ZONE             | P.P.M. | WATER TEMP. | TIME    | WATER DEPTH | TOTAL COVER |                      |             |      |
| JUNE 19 | OW               | 6.65   | 72°F        | 9:40AM  | 12"         | 0%          | 3.74                 | 41.18       | 7.75 |
|         | WZ               | 7.30   | 79°F        | 10:05AM | 3/4"        | 60%         | 3.00                 | 41.78       | 7.68 |
|         | SL               | 6.68   | 76°F        | 9:10AM  | 1/2"        | 9%          | 3.24                 | 40.87       | 7.25 |
| JULY 21 | OW               | 6.53   | 80°F        | 9:35AM  | 18"         | 0%          | 2.60                 | 41.95       | ---  |
|         | SL               | 6.65   | 83°F        | 10:00AM | 1"          | 0%          | 3.60                 | 39.33       | 7.90 |
| SEPT. 6 | OW               | 7.40   | 82°F        | 4:00PM  | 30"         | 0%          | 0.00                 | 46.36       | 8.28 |
|         | SL               | 7.70   | 84°F        | 3:45PM  | 1/2"        | 0%          | 0.00                 | 45.45       | 8.15 |
| OCT. 8  | OW               | 8.25   | 71°F        | 6:00PM  | 26"         | 0%          | 0.00                 | 49.72       | 7.60 |
|         | SL               | 8.20   | 73°F        | 5:45PM  | 3"          | 0%          | 0.00                 | 52.76       | 7.38 |
| DEC. 11 | OW               | 10.95  | 42°F        | 3:05PM  | 18"         | 0%          | 0.00                 | 52.24       | 7.65 |
|         | SL               | 10.75  | 42°F        | 2:15PM  | 1/2"        | 0%          | 0.00                 | 51.85       | 7.35 |

TABLE 11. AVERAGES OF DUPLICATE ANALYSIS RUN EACH SAMPLING DATE FOR DISSOLVED OXYGEN, FREE CARBON DIOXIDE, ALKALINITY AND pH. THE SAMPLES WERE TAKEN ONE-HALF TO TWO INCHES BELOW THE WATER SURFACE IN OPEN WATER (OW), ZONE OF WEED GROWTH (WZ), AND ALONG THE SHORE LINE (SL). LUBBOCK COUNTY, TEXAS. SUMMER, FALL, WINTER 1963. LAKE 111.

| DISSOLVED OXYGEN |      |        |            |         |             |             |        |  |        | FREE CO <sub>2</sub> | ALKA-LINITY | pH |
|------------------|------|--------|------------|---------|-------------|-------------|--------|--|--------|----------------------|-------------|----|
| DATE             | ZONE | P.P.M. | WATER TEMP | TIME    | WATER DEPTH | TOTAL COVER | P.P.M. |  | P.P.M. |                      | P.P.M.      |    |
| JUNE 18          | OW   | 6.58   | 70°F       | 10:05AM | 28"         | 0%          | 9.97   |  | 49.72  |                      | ---         |    |
|                  | WZ   | 1.10   | 69°F       | 10:25AM | 6"          | 70%         | 13.47  |  | 79.00  |                      | ---         |    |
|                  | SL   | 7.75   | 76°F       | 9:50AM  | 1 1/2"      | 0%          | 2.65   |  | 54.29  |                      | ---         |    |
| JULY 21          | OW   | 8.10   | 86°F       | 6:30PM  | 12"         | 10%         | 0.00   |  | 88.10  |                      | 7.58        |    |
|                  | WZ   | 5.50   | 86°F       | 5:00PM  | 11"         | 60%         | 2.00   |  | 90.50  |                      | 7.63        |    |
|                  | SL   | 6.00   | 85°F       | 5:30PM  | 1 1/2"      | 99%         | 0.00   |  | 94.00  |                      | 7.93        |    |
| SEPT. 6          | OW   | 9.75   | 83°F       | 5:58PM  | 21"         | 0%          | 0.00   |  | 42.55  |                      | 8.90        |    |
|                  | SL   | 9.70   | 84°F       | 5:45PM  | 1 1/2"      | 0%          | 0.00   |  | 41.94  |                      | 8.85        |    |

TABLE III. AVERAGES OF DUPLICATE ANALYSES RUN EACH SAMPLING DATE FOR DISSOLVED OXYGEN, FREE CARBON DIOXIDE, ALKALINITY AND pH. THE SAMPLES WERE TAKEN ONE-HALF TO TWO INCHES BELOW THE WATER SURFACE IN OPEN WATER (OW), ZONE OF WEED GROWTH (WZ), AND ALONG THE SHORE LINE (SL). LURROCK COUNTY, TEXAS. SUMMER, FALL 1963. LAKE V.

| DATE    | DISSOLVED OXYGEN |        |               |        |                | FREE<br>CO <sub>2</sub> | ALKA-<br>LITY | pH     |
|---------|------------------|--------|---------------|--------|----------------|-------------------------|---------------|--------|
|         | ZONE             | P.P.M. | WATER<br>TEMP | TIME   | WATER<br>DEPTH | TOTAL<br>COVER          |               |        |
| JUNE 19 | OW               | 6.15   | 91°F          | 4:55PM | 8"             | 6%                      | 1.50          | 63.14  |
|         | WZ               | 5.25   | 89°F          | 4:25PM | 6"             | 80%                     | 1.75          | 67.65  |
|         | SL               | 5.70   | 91°F          | 4:05PM | 1"             | 6%                      | 1.75          | 61.92  |
| JULY 21 | OW               | 8.65   | 89°F          | 2:30PM | 6"             | 10%                     | 0.00          | 101.26 |
|         | WZ               | 6.65   | 87°F          | 2:27PM | 4"             | 99%                     | 3.00          | 101.90 |
|         | SL               | 7.90   | 91°F          | 2:15PM | 1/4"           | 80%                     | 0.00          | 85.10  |

TABLE IV. AVERAGES OF DUPLICATE ANALYSIS RUN EACH SAMPLING DATE FOR DISSOLVED OXYGEN, FREE CARBON DIOXIDE, ALKALINITY, AND pH. THE SAMPLES WERE TAKEN ONE-HALF TO TWO INCHES BELOW THE WATER SURFACE IN OPEN WATER (OW), ZONE OF WEED GROWTH (WZ), AND ALONG THE SHORE LINE (SL). LUBBOCK COUNTY, TEXAS. SUMMER 1963. LAKE X.



APPENDIX V.

Wildlife and Soil Analysis Data

TABLE I RESULTS OF A SURVEY OF TEN LANDOWNERS IN THE LUBBOCK AREA CONCERNING THE AVAILABILITY OF THEIR PLAYA LAKES FOR LEASE AS A STUDY ON WILDLIFE UTILIZATION. SUMMER 1963. LUBBOCK COUNTY, TEXAS.

| Landowner<br>Name and<br>Address                                                | Five year<br>use<br>contract | Use of<br>water<br>supply | Plants, crops<br>trees, shrubs | Approval of<br>all cultural<br>practices | Farmers<br>share of<br>cost               | Permission<br>to sample<br>lake 10 yrs. | Control<br>hunting and<br>fishing |
|---------------------------------------------------------------------------------|------------------------------|---------------------------|--------------------------------|------------------------------------------|-------------------------------------------|-----------------------------------------|-----------------------------------|
| Bill Burgett<br>Route 1<br>Shallowater, Tex.<br>(operator)                      | No                           | Irrigation<br>from Lake   | No                             | No                                       | Yes                                       | No                                      |                                   |
| L. M. Hobgood<br>Lubbock County<br>(owner)                                      | No                           | Good supply<br>of water   | Yes                            | Cattle<br>Graze<br>on Land               | No                                        |                                         | Yes                               |
| Carl Phillips<br>Hale County<br>2 1/2 Miles N. of<br>Abernathy, Tex.<br>(owner) | No                           | Irrigation<br>from Lake   | No                             | No                                       | No                                        | No                                      | No                                |
| Joe Loveless<br>Hale County<br>Abernathy, Tex.<br>(owner)                       | No                           | Yes                       | No                             | No                                       | Yes<br>\$350.<br>to<br>\$400.<br>per acre | Yes                                     |                                   |
| Joe Walker<br>(operator)<br>Slaton, Tex.<br>Lubbock County                      | No                           | Irrigation<br>from Lake   | No                             | \$500-<br>\$600<br>per<br>acre           | No                                        | No                                      | No                                |
| Roy Collins<br>(owner)<br>Slaton, Tex.<br>Op. Walter<br>Stollie<br>Garza County | No                           | May use for<br>irrigation | No                             | No                                       | Will<br>not<br>say                        | No                                      | No                                |

TABLE I CONTINUED

| Landowner<br>Name and<br>address                                      | Five year<br>use contract | Use of<br>water supply                                                                                                  | Plant, crops,<br>trees, shrubs        | Approval of<br>all cultural<br>practices | Farmers share<br>of cost | Permission<br>to sample<br>lake 10<br>years | Control<br>hunting and<br>fishing |
|-----------------------------------------------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------|---------------------------------------|------------------------------------------|--------------------------|---------------------------------------------|-----------------------------------|
| Beaver and Virgil<br>Smith<br>Route 1, Post,<br>Texas<br>Garza County | No                        | Water used<br>for irri-<br>gation for<br>years                                                                          | No                                    | No                                       | No                       | No                                          | No                                |
| Floy Robinson<br>(owner)<br>Post, Texas                               | Yes                       | No use of<br>water. 1/2<br>of lake<br>used for<br>cattle<br>water.                                                      | Yes                                   | No                                       | No                       | No                                          | No                                |
| Keith Kemp<br>Route 1<br>Post, Texas                                  | No                        | No use of<br>water.<br>Annual run-<br>off into<br>lake not<br>adequate to<br>maintain<br>fish popula-<br>tion or ducks. |                                       |                                          |                          |                                             |                                   |
| S. C. Scott<br>(owner)<br>Post, Texas                                 | No                        |                                                                                                                         | Cattle<br>Graze<br>on<br>lake<br>area |                                          |                          |                                             |                                   |

Table II. A checklist giving estimated numbers of each species observed during the 1963 season. Numbers were totaled for the four modified lakes and for the six unmodified lakes in the study. Summer-Winter 1963. Lubbock County, Texas.

| Class Aves             | Species Observed                                   | Modified<br>Lakes | Unmodified<br>Lakes |
|------------------------|----------------------------------------------------|-------------------|---------------------|
| Order Anseriformes     |                                                    |                   |                     |
| 1.                     | <u>Anas platyrhynchos</u> - mallard                |                   | 5                   |
| 2.                     | <u>Anas carolinensis</u> - green-winged teal       |                   | 590                 |
| 3.                     | <u>Anas discors</u> - blue-winged teal             | 28                |                     |
| 4.                     | <u>Spatula clypeata</u> - shoveller                | 2                 |                     |
| 5.                     | <u>Aythya americana</u> - redhead                  |                   | 200                 |
| 6.                     | <u>Aythya valisineria</u> - canvas-back            | 2                 |                     |
| Order Falconiformes    |                                                    |                   |                     |
| 1.                     | <u>Circus cyaneus hudsonius</u> - marsh hawk       |                   | 35                  |
| 2.                     | <u>Falco sparverius</u> - sparrow hawk             |                   | 1                   |
| Order Gruiformes       |                                                    |                   |                     |
| 1.                     | <u>Fulica americana</u> - coot                     | 5                 | 25                  |
| 2.                     | <u>Grus canadensis</u> - sandhill crane            |                   | 200                 |
| Order Charadriiformes  |                                                    |                   |                     |
| 1.                     | <u>Catoptrophorus semipalmatus</u> - willet        |                   | 57                  |
| 2.                     | <u>Totanus melanoleucus</u> - greater yellow-legs  |                   | 75                  |
| 3.                     | <u>Totanus flavipes</u> - lesser yellow-legs       |                   | 300                 |
| 4.                     | <u>Recurvirostra americana</u> - avocet            |                   | 4                   |
| 5.                     | <u>Charadrius vociferus</u> - killdeer             | 10                | 53                  |
| 6.                     | <u>Erolia fuscicollis</u> - white rumped sandpiper |                   | 5                   |
| 7.                     | <u>Erolia manutilla</u> - least sandpiper          |                   | 30                  |
| Order Columbiformes    |                                                    |                   |                     |
| 1.                     | <u>Zenaidura macroura</u> - mourning dove          | 5                 | 15                  |
| 2.                     | domestic pigeon                                    | 300               | 50                  |
| Order Caprimulgiformes |                                                    |                   |                     |
| 1.                     | <u>Chordeiles minor</u> - nighthawk                | 10                | 40                  |



Table II. Continued:

| Class Aves          | Species Observed                                         | Modified<br>Lakes | Unmodified<br>Lakes |
|---------------------|----------------------------------------------------------|-------------------|---------------------|
| Order Passeriformes |                                                          | 40                | 765                 |
| 1.                  | <u>Hirundo rustica erythrogaster</u> - barn swallow      |                   | 12                  |
| 2.                  | <u>Eremophila alpestris</u> - horned lark                |                   | 400                 |
| 3.                  | <u>Calamospiza melanocorys</u> - lark bunting            |                   | 6                   |
| 4.                  | <u>Agelaius phoeniceus</u> - red-wing black bird         |                   | 45                  |
| 5.                  | <u>Euphagus cyanocephalus</u> - Brewer's blackbird       |                   | 500                 |
| 6.                  | <u>Molothrus ater ater</u> - Eastern cowbird             | 60                | 400                 |
| 7.                  | <u>Passer domesticus</u> - English sparrow               |                   | 7                   |
| 8.                  | <u>Tyrannus verticalis</u> - western kingbird            |                   |                     |
| Class Amphibia      |                                                          |                   |                     |
| Order Caudata       |                                                          | 1000s             | 100s                |
| 1.                  | <u>Ambystoma tigrinum</u> - tiger salamander             |                   |                     |
| Order Salientia     |                                                          | 100s              | 1000s               |
| 1.                  | <u>Bufo woodhousii</u> - garden toad                     | 1160              | 65                  |
| 2.                  | <u>Rana pipiens</u> - leopard frog                       | 300               | 300                 |
| 3.                  | <u>Pseudacris clarkii</u> - spotted frog                 |                   | 60                  |
| 4.                  | <u>Bufo terrestris americanus</u> - common american toad |                   | 75                  |
| 5.                  | <u>Bufo pugnatus</u> - plains toad                       |                   | 1700                |
| 6.                  | <u>Scaphiopus couchii</u> - sonoran spadfoot             |                   |                     |
| Class Reptilia      |                                                          |                   |                     |
| Order Squamata      |                                                          | 10                | 15                  |
| 1.                  | <u>Sceloporus undulatus</u> - rough-scaled lizard        | 5                 | 20                  |
| 2.                  | <u>Cnemidophorus sexlineatus</u> - six-lined racerunner  |                   |                     |
| Suborder Serpentes  |                                                          |                   | 1                   |
| 1.                  | <u>Thamnophis marciana</u> - checkered gartersnake       |                   |                     |
| Order Testudinata   |                                                          | 100               | 7                   |
| 1.                  | <u>Kinosternon flavescens</u> - yellow mud turtle        |                   |                     |

Table III Contains soil test results and classifications on Lake III, Hufstedler, Lake IV, LCC, and Lake V, Kittens.

| Soil Test Classification         | LAKE III          | LAKE IV             | LAKE V              |
|----------------------------------|-------------------|---------------------|---------------------|
| Soil Reaction pH                 | 6.90              | 7.80                | 8.00                |
| Organic Matter $\%$<br>level     | .30<br>Very low   | 0.90<br>low         | 0.50<br>very low    |
| Predicted Nitrogen Level         | Very low          | low                 | very low            |
| $P_{25}^{0}$ # per acre<br>level | 300<br>Very high  | 238<br>very high    | <br>very high       |
| $K_2^0$ # per acre<br>level      | 1200<br>Very high | 1200<br>very high   | 1200<br>very high   |
| Ca0 # per acre<br>level          | 8680<br>Very high | 14,000<br>very high | 14,000<br>very high |
| Salinity Hazard salt<br>#/acre   | 78<br>Very low    | 364<br>very low     | 416<br>very low     |
| Sodium #/acre                    | 120               | 140                 | 340                 |